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ABSTRACT

Project Marine Ecology Research (MER) is an ecological unit designed to involve secondary students in the study of the marine biome. The teachers are also involved with MER through inservice participation and materials preparation. The unit is designed to be incorporated within the existing science curriculum. Specifically, the activities concern the study of the San Francisco Bay area--its geology, geography, climate and weather, wave and tide action, and currents. Each of the four activity sections are arranged similarly. The Introduction includes background information for the teacher and a list of educational objectives. The appendix contains the activities as well as charts, maps, statistics, and other pertinent information. Each section ends with a bibliography. (MA)

ED106088

MARINE ECOLOGY RESEARCH
Resource Units
Grades 7-9

U.S. DEPARTMENT OF HEALTH
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

SE 018 507

contra costa county schools
Floyd Marchus, Superintendent

DRAFT

September 1974

NOTE

The intent of developing resource units for grades 7-9 for "Project Marine Ecology Research" was to furnish classroom teachers with resource material which could be reviewed prior to the involvement of their students in the ongoing project itself.

The basic intent of Project MER is to bring about behavioral change and environmental awareness in our students. It is recognized that any permanent positive change will undoubtedly result only through personal, individual involvement. These resource units will prepare students for those types of field work within their general competency. Field work and monitoring is predicated upon a complex series of skills. It is hoped that these resource units will provide the link between the academic world of the school and the real world of the San Francisco Bay Estuary Complex.

A summary of the final report for National Science Foundation Grant GW-6717 follows as an introduction to those of you who are not familiar with the project. Your attention is directed to the materials immediately following the final report. Herein, information is available which will help you in taking the next step: Involvement of your students in real time learning experiences through Project MER.

Cordially yours,

William H. Landis, Ed. D., Coordinator,
Mathematics and Science
Contra Costa County
Superintendent of Schools Office

FINAL REPORT
NSF GRANT GW - 6717

This project had its beginnings some five years ago in a meeting at the Contra Costa County Department of Education, Pleasant Hill, California. Those present - teachers, students, scientists, environmentalists - shared a common belief that environmental problems were everybody's business, and that students could and should be able to make important contributions toward the solution of some of these problems.

In particular those present discussed the fact that, while there was a great deal of community concern over aquatic pollution of the San Francisco Bay-Delta-Estuary Complex, relatively little was known about the ecology of this important water ecosystem. Thus, the program which came to be called Marine Ecology Research (MER), was conceived, a program which would involve students in a monitoring program to provide information critical to the future of the San Francisco Bay-Delta-Estuary Complex.

Through faith, hard work and the creative input of countless individuals, the program developed in the ensuing years. From the earliest stages, the confidence and support of the Contra Costa County Superintendent of Schools Office made it possible for the program to become a reality. Any program, however great its potential, will die "aborning" without adequate financial backing. That this was not the fate of MER can be attributed to the support given by many groups and individuals. In the beginning, the Contra Costa County Superintendent of Schools Office provided clerical and administrative services, while the Alameda County Schools Office and the Diocese of the Oakland Department of Education absorbed many of the costs of publication. The funds for development of curriculum materials came from surplus California Fish and Game Fine Funds released by the Contra Costa County Board of Supervisors, the Rosenberg Foundation which supplied the first program grant, the National Science Foundation and ESEA Title III grants. Several local industries have also contributed materials, money and services. The U.S. 12th Naval District provided MER a home for its Point Molate Marine Laboratory.

More than eighty teachers and their classes were involved in the initial development and piloting of curriculum materials vital to the MER program. Teachers and students devoted weekends to building the Point Molate facility, literally "from the ground up." While financial support has been an important factor in the development of MER, the people involved have made the program what it is. A science Advisory Committee headed by Dr. Fred Tarp, and including representatives from governmental, industrial, educational and environmental agencies, provided considerable assistance and advice. Mr. George Castellani, appointed director of MER at its inception in February of 1969, supplied the creative leadership over the ensuing highly productive years.

During the last two years, an NSF grant has made it possible for selected science teachers from Alameda and Contra Costa Counties to learn about Marine Biology and the problems of the San Francisco Bay and its estuarine areas. It also provided an opportunity for these teachers to develop, test and reproduce instructional guides and teaching units (attached). This material has been distributed to all the schools in these two populous counties thereby providing the desired implementation of Foundation supported programs. Further implementation of the materials developed is assured as MER is continuing under Title III support for at least two more years.

Project MER, Teacher Training, has prepared teachers for direct involvement in the 'parent' Project MER with their classes. It has been my pleasure to take over the direction of this teacher training project from Mr. George J. Castellani, the original director, who is continuing to direct the development and implementation of the project under an ESEA Title III grant. Dr. Fred Tarp, a recognized authority on the ecology of the San Francisco Bay Area, served as principal lecturer and course instructor with Professor Lawrence Lowery of the University of California at Berkeley and myself also serving on the instructional staff.

The instructional guides and curriculum materials developed (attached) were prepared by two writing committees of teachers. One committee prepared materials for the high school level classes while the second committee prepared units for the intermediate grades. All the materials developed for the intermediate grades were not reproduced at this time because of the lack of time and demand for completion of units determined to be more relevant to MER.

The remainder of this report will concern itself with the activities of the past two years, the time during which I directed the teacher training program.

In November and December of 1972 schools and teachers in the two counties, Alameda and Contra Costa, were notified about this program. Notification took the form of publications from the two county superintendents offices, MER letters, ongoing NSF teacher institutes memos, San Francisco Bay Area Science Fair notices and word of mouth. Fifty teachers were accepted though many more applied.

The program was planned for eight (8) Saturday sessions in the Spring of 1973, six (6) weeks in the summer followed by seven (7) Saturday meetings during the remainder of the year (see outline enclosed). As the program moved along variations in the outline were indicated and changes made. It also became evident in the Spring that the teachers desired to write up units that could be utilized in their classes and passed on to their associates and so arrangements were made to do so. The high school teachers formed a committee which completed its publication after the summer session (see the attached). The intermediate teachers then decided on a similar publication for their use. A request was made to the Foundation to extend the grant to June 30, 1974 so that this could be accomplished. The request was granted. Due to the energy crisis, some of this work had to be delayed until gasoline became available. I am pleased to state that the task was completed (see the attached).

Of the fifty-three (53) teachers who started, forty remained for the Summer and twenty-eight (28) completed the program. (Roster included).

In my opinion this was one of the best NSF supported programs I have been associated with in my eighteen years involvement with Foundation programs. Implementation of materials developed and involvement by schools and teachers has persisted from the beginning of the program.

Robert A. Rice,
Director
MER, Teacher Training

GENERAL INFORMATION SHEET

Project MER

1. *What is Project MER?*

Project MER (Marine Ecology Research) is a program designed by Contra Costa and Alameda County teachers to involve students in a study of the marine biome as part of an ecological unit for incorporation in their class instruction.

The Point Molate Marine laboratory at Richmond was developed with special facilities for the instruction of intermediate students. The activities offered provide a "hands on" experience designed to stimulate student interest and to provide experiences which would otherwise not be possible in a typical classroom.

2. *Who supports Project MER?*

Project MER has been supported by a series of grants received by the Contra Costa County Superintendent of Schools Office, to involve students in our counties in Marine ecology.

Project MER was initially supported by funds from the Contra Costa County Board of Supervisors through their California Fish and Game Fine Fund money. Additional support has been provided by the Offices of the Superintendent of Schools in Alameda and Contra Costa Counties. A series of grants have been received; the first grant in 1971 from the Rosenberg Foundation, a grant during 1971-72 from the National Science Foundation. The program is presently supported under an ESEA, Title III grant.

3. *What agencies are supporting the activities of the students?*

The California Department of Fish and Game, U.S. Department of Fish and Wildlife, the Environmental Protection Agency, the Contra Costa County Water Agency, the State Department of Health and the Contra Costa County Department of Health have supported this program by offering considerable consultant assistance.

4. *What kind of program is offered to students participating in Project MER?*

Activities involving the following are included:

Studies on salinity
Studies on plankton
Similarities and differences among the invertebrates
   and within invertebrate groups
Adaptation of organisms as evidenced by zonation
Categorizing and itemizing pelagic forms
Determination of the age of fish, using scales and otoliths

5. *Who may participate in this program?*

This program is available to public and private school students in Contra Costa and Alameda Counties. Arrangements permit a limited number of students outside these two counties to participate. Since the number of classes is limited by tides, those wishing to participate must indicate their desires early to insure participation.

6. *What grades may participate in Project MER?*

MER includes two programs, one which has been established for students who are in ninth grade biology, or in tenth, eleventh or twelfth grades. The second program is designed for students in seventh through ninth grade classes. This information sheet relates to the latter program.

7. *How long is a training session at the Point Molate Marine Laboratory?*

A typical session runs for four hours. The selection of time is dependent upon tidal conditions. Normally, the classes start between 8:30 a.m., 10:30 a.m. and 12:30 p.m. During the four-hour session, each student will be involved in a variety of activities.

8. *What costs are involved in participation?*

Schools must arrange to supply their own transporation to the Point Molate Marine Laboratory and to cover the remaining classes of the teacher who is bringing the class. The group must be accompanied by their teacher. At present there are no direct charges made to districts, the costs of the instructional program at the marine laboratory are covered by the project.

9. *What are the responsibilities of the teacher bringing a class to the marine lab?*

Aside from submitting a *Scheduling Request Form*, it is necessary, according to state law, for each student who comes to the laboratory to have a properly completed *Parent Consent Slip* which must remain at the laboratory. The format for this consent slip will be sent to each teacher who requests scheduling information. Teachers must arrange transportation for their classes.

10. *How many classes may a teacher take?*

There is no specific limit to the number of classes a teacher may take. However, due to the limited number of available dates, every effort is being made to see that all schools have an equitable chance to participate in the program.

11. *How many students may come in a class?*

The ideal number of students is between 26 and 28. However, if a teacher has a class of over 30 students, he must check with the Project Director for approval of these extra students. We are most anxious to see that no student is denied an opportunity because of his ability. Since the teacher will want to utilize the student experiences received at Point Molate as part of his class instruction, it is important that students are not selected from a series of classes and that each class should come as a whole unit.

General Information Sheet - Project MER (Continued)

12. *How much training does a teacher need in order to participate in this program?*

A component of Project MER is to provide teachers with sufficient background in marine science to enable them to feel comfortable in dealing with this subject in their classrooms. Therefore, it is not only unnecessary to have had previous training in marine science but, in some ways, desirable. The Visiting Instructor experience will provide the teacher with background information in marine science, along with teaching strategies necessary to utilize this material in his classroom.

13. *What resources are available to help the teachers?*

Along with the materials included in this Resource Unit, the MER staff and local teachers have developed materials for high school teachers which they are using in their classes. While they are not appropriate for students' use on the intermediate level, they can be provided to participating intermediate teachers since they contain background information of value. These materials include instruction in analyzing for water quality and assessing populations along with a series of keys to the local organisms.

14. *Are there opportunities for teachers to become involved in the development of curriculum?*

Yes. At the present time there are additional activities which have to be prepared for the study of Bay Area waters. Teachers in Contra Costa and Alameda Counties are invited to join with others in the development of additional curriculum materials. Special assistance is needed in developing materials for students in elementary and intermediate grades. Interested teachers should notify the Project Director.

15. *How does one go about scheduling a class?*

A *Scheduling Request Form* and a list of available dates is available upon request to any teacher who desires to bring a class to Point Molate. The form should be completed and signed by the appropriate administrator in the school and returned to the Project Director, Contra Costa County Superintendent of Schools Office, 75 Santa Barbara Road, Pleasant Hill, CA, 94523. If there are any questions concerning dates and times, do not hesitate to call (415) 937-4100, Ext. 368.

The Resource Units to Marine Ecology Research were prepared by intermediate and junior high school teachers in Alameda and Contra Costa Counties as part of a National Science Foundation grant awarded to the Contra Costa County Superintendent of Schools Office, Floyd Marchus, Superintendent.

Dr. William H. Landis, Coordinator of Mathematics and Science for County Schools Department, acted as Administrative Assistant for the Superintendent; and Professor Lawrence F. Lowery, Department of Science Education, University of California Berkeley, acted as instructor and consultant for the project.

The materials were finalized for publication by Project Director Robert A. Rice, Berkeley Unified School District and Principal Instructor Dr. Fred H. Tarp, Chairman, Department of Biology, Contra Costa College, San Pablo.

Teachers involved in the development of Resource Units include:

Karl D. Bartle
Urban Studies Center, Oakland

Francis L. de los Reyes
Portola Jr. High School, El Cerrito

Robert R. Dias
Nielsen School, Dublin

Steven J. Duke,
T. D. Wells School, Dublin

Michael B. Harper
Los Medanos School, Dublin

Linda R. Henika
Winton Jr. High School, Hayward

Jean Kanstein
Oak Grove Intermediate, Concord

Joyce K. Livergood
Shady Grove School, Catro Valley

Wilbur C. McEachin
Madison Jr. High School, Oakland

Beatrice A. Moore
Pleasant Hill Intermediate, Pleasant Hill

Donald J. Paulsen
El Dorado Intermediate, Concord

Sister Adrienne C. Piennette
All Saints' School, Hayward

Patricia H. Porter
St. Joseph's School, Fremont

Hilario Puente
Oakley School, Oakley

Leonard S. Reppond
T. D. Wells School, Dublin

Anna M. Sypolt
Oak Grove Intermediate, Concord

Henry F. Watty
Antioch Jr. High School, Antioch

Herbert Weslar
Pinole Jr. High School, Pinole

Teachers involved in the development and editing of Resource Units:

Hazel S. Adams
Inland Valley School, Orinda

Jane Helrich
Holbrook Elementary School, Concord

Frank N. Stager
Donlon School, Dublin

Florence Yaffe
Portola Jr. High School, El Cerrito

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geology

GEOLOGY OF THE SAN FRANCISCO BAY AREA - DELTA REGION

INTRODUCTION

This is an historical background, showing the evolution of the San Francisco Bay Area from a low land mass to the area it is now.

I. Geological History
II. Geological Processes
III. Dynamics of Earth Movements
IV. Geochronology
V. Rocks and Minerals

I. THE REGION OF THE BAY DURING THE PLIOCENE EPOCH

The landscape of the San Francisco Bay region was quite different during the Pliocene epoch from what it is today; in fact, its appearance at that time gave no hint of the topography that was to develop. During most of the Pliocene epoch the present day bay lands were part of the highlands which drained to the east; the Berkeley Hills did not exist, and their area and the area of the present rolling hill lands to the east were largely occupied by a broad lowland. In fact, during the later part of the preceding epoch (the Miocene) part of this eastern area was below sea level and was occupied by an arm of the sea which connected with the Pacific Ocean south of the present bay region, and extended up the west side of the then central valley which lay between the Coast Ranges region and the Sierra Nevada.

At many localities between the present Berkeley Hills and the San Joaquin Valley, the deposits of this early bay have been tilted up by earth movements and so eroded as to be exposed to view. They carry fossil remains of marine animals of shallow-water type. In the latitude of Berkeley, the extreme western limit of this ancient bay was probably not far west of the present western face of the Berkeley Hills. There its shore or near-shore deposits are exposed in two comparatively narrow bands of variable thickness about four miles east of the eastern shore of the present San Francisco Bay. To the north, deposits of the ancient bay are well exposed on the east shore of San Pablo Bay and remnants have also been found north of Carquinez Strait and Suisun Bay.

Toward the end of the Miocene (according to invertebrate paleontologists) or early in the Pliocene (according to vertebrate paleontologists) a progressive replacement of the bay conditions of deposition by land condition of deposition began. The bay gradually became more and more restricted, and finally disappeared; and, as seen in the west face of the Berkeley Hills, the thin lowest belt of the ancient bay's western fringe of sediments was covered by alluvium. Somewhat later bay conditions were reestablished for a while; but soon again the marine strata (assigned to the Neroly formation) were covered by land-laid deposits and there were no more marine incursions. Some miles to the east, marine conditions lasted longer, for marine strata grade through blackish water deposits into fresh-water deposits. Still farther east, in the area southwest of Mount Diablo, marine conditions appeared to have lasted the longest, for 1,000 feet of marine beds (Alamo formation) were deposited above the Neroly beds during the lower Pliocene, before alluvial conditions were finally established.

Judging from the vertebrate fossils found in the deposits, the alluvial plain persisted throughout the lower Pliocene and through much if not all of the middle Pliocene. During this time the earth's crust in the region was undergoing slow deformation from compressional forces acting from southwest to northeast, which tended to produce a trough-like depression extending roughly in a northwest direction and deepening eastward for a number of miles from the present area. The movement was slow enough so that the alluvial deposits spread by the streams kept pace with the sinking and in the course of time built up a mass of sediments with a maximum thickness of possibly 5,000 feet. Apparently, while the trough was deepening the west border lands were slowly rising, for there is no evidence to the west of material overlap by the land deposits of the sequence, as commonly occurs in basin filling.

In the midst of this development (in the lower Pliocene), volcanic activity broke out in the border belt between the areas of elevation and depression. This resulted in the 1,500 foot series of lava flows and associated deposits of volcanic ash and breccia (Moraga formation) which now characterizes the summit region of the Berkeley Hills. The series may be seen along Grizzly Peak Boulevard and in the high road cuts along the highway east of the Broadway low-level tunnel. Both Grizzly Peak and Bald Peak and the ridges of which they are the culminating peaks, stand out above the general level because of the resistant lavas of which they are composed.

Starting with the outline of the bay valley, or perhaps with the mid-Pleistocene disturbance, the whole body of present hill lands, from the immediate bay region to the Great Valley, was slowly uplifted - slowly enough so that the main river (combined Sacramento and San Joaquin) could maintain its course from the Great Valley across the uprising land. The cutting action of this river produced Carquinez Canyon (now Carquinez Strait) which ultimately reached a depth of 800 to 900 feet. Similar action to the west of the bay valley, possibly at the same time, cut Golden Gate Canyon (now Golden Gate Strait) to a depth of more than 700 feet. East of San Francisco Bay this phase of elevation and more recent canyon cutting appear to have taken place chiefly in the upper Pleistocene, probably mostly in the earlier part of the upper Pleistocene. Some evidence of differential uplift may be interpreted as indicating movement in recent time, and such action may not yet have ended.

The valleys of the Coast Ranges are as varied in origin as the mountains which confine them. Some, such as the Santa Clara Valley, are down-dropped or down-tilted blocks. Others, like the Livermore basin and the basin of San Francisco Bay are irregular downwarps complicated by faulting and modified by erosion and filling. Some of the valleys north of San Pablo follow synclines. These have been carved either by streams which came into being on original folds or by streams that originated along belts of weak rock after an earlier peneplantation. Other valleys were clearly carved along fault zones, and still others have had complex histories involving periods of filling and re-excavation as well as deformation.

Large areas in the Coast Ranges have a fault-trellis drainage pattern in which the principal valleys have been eroded along fault lines. These valleys, although paralled for long distances, commonly diverge, and a dentritic or tree-like pattern develops in the broad inter-fault areas. This type of fault-trellis patterns is particularly well displayed in the San Mateo quadrangle.

The Diablo Range, that is, all of the coast ranges east of Santa Clara Valley, is divided into several smaller northwest-trending ridges by a number of prominent valleys, largely controlled by faults. Among these are Sunol and Calaveras Valleys. The western margin of Livermore basin itself is determined by a major fault.

In the middle Miocene, after a time of widespread inundation, a pronounced mountain-building (orogenic) movement took place, at which time much of the structural framework of the present Coast Ranges is believed to have been established. Although the present topography of the Coast Ranges reflects to some extent the influence of the earlier periods of deformation, the general direction and localization of the ranges had their inception at this time. Later diastrophisms, culminating during the mid-Pleistocene, followed these regular major trends.

Throughout the late Jurassic and all of the Cretaceous, a time interval of at least 50 million years, the Coast Ranges, including the entire San Francisco Bay region, except the eastern part in eastern Sacramento and the San Joaquin Counties, was covered by a shallow sea. To the west, probably more than 10 miles off the present coast, lay a mountain range made up of the old crystalline rocks. In the early stages of downsinking of the geosynclinal trough this range was high, with many sharp canyons occupied by streams of high gradient. As time progressed this range was lowered by erosion, relief decreased and the streams became broader and more sluggish. There were probably periods of slight rejuvenation and local re-elevation, but in general the wearing down of the old land mass, which is now buried beneath thousands of feet of marine waters, continued.

The Knoxville stage of the Franciscan-Knoxville group is chiefly made up of dark, silty, clay shales with thin interbeds of fine-grained sandstone. The dark clay shales of the Knoxville are identical with those in the Franciscan. Conglomerates occur in the Knoxville but they are not abundant. They consist of small, well rounded pebbles of black recrystallized chert and various types of igneous porphyries; these are the same types that predominate in the Franciscan conglomerates.

Dark impure limestones occur in the Knoxville as thin lenses and as concretions in the shales; many of these limestones are follisiferous.

In several places thin flows of pillow basalt and thin impure red cherts are found in the lower part of the Knoxville well above typical Knoxville fossils.

Fossils, other than the small poorly preserved radiolaria and foraminifera in the chert and limestones, are rare in the Franciscan. The best fossils found thus far are two ichthyosaur snouts found in Franciscan chert boulders in western San Joaquin County. These were carefully studied by Dr. C. L. Camp of the Department of Paleontology, University of California, who concluded that they were of late Jurassis age. Fossils are fairly abundant in the Knoxville stage and clearly show that these beds also are of late Upper Jurassic age.

Although the Franciscan-Knoxville group is fairly thick, maximum thickness is probably 30,000 feet, the rocks are chiefly coarse clastics and volcanics that accumulated rapidly, and therefore do not represent an excessively long period of geologic time. The geosyncline created at this time received sediments during the late Jurassic and throughout the Cretaceous and was the birthplace of the Coast Ranges as they are known today.

When stripped of its weathered over burden the Franciscan sandstone is hard, fresh, firmly cemented rock that makes excellent road metal. A number of quarries in Franciscan sandstone have been opened and an enormous amount of crushed sandstone taken from them.

All of the maganese mined in the Coast Ranges is associated with radiolarian chert. The maganese was deposited at the same time as the chert and occurs in the form of maganese carbonate or a high-silica maganese ore, interbedded with the chert. The Ladd mine in eastern Alameda County is the largest maganese mine in the state and surface oxidized ore was mined as early as 1866. The Ladd mine was operated continuously during World War I and produced several tons of thousands of tons of maganese ore. The second largest maganese mine, the Buckeye, is located in Stanislaus County about a mile from the San Joaquin County line. This mine yielded about 20,000 tons of high-grade maganese ore during World War II. Several thousand tons of ore still remain. There are scores of smaller maganese mines that have yielded from a few hundred to 5,000 tons of ore in Sonoma, Napa, Marin, Alameda, San Joaquin and Santa Clara Counties. Should there be an appreciable advance in the price of and a cheap process deviced for the utilization of high silica present, the bay counties could supply a substantial tonnage of low to medium grade ore.

The mineral chromite occurs as disseminated grains in the serpentine and in places, as irregular magmatic ore bodies. During World War I small chrome bodies were mined in practically all of the bay counties and a small amount of chrome was mined during the second World War.

Magnesite is another important substance which occurs in the Coast Ranges of California only in serpentine. The largest magnesite mines in the region are in outer Santa Clara County, near the crest of the Diablo Range. Smaller, but more numerous, magnesite mines are in Napa County, both north and south of Pope Valley. Magnesite occurs as veins and irregular areas in serpentine. The alteration of the original olivine usually stops with serpentine but if there is further alteration, especially with the aid of carbon dioxide and water, magnesite is formed.

A third material of economic importance which occurs primarily in serpentine is chrysotile asbestos. Although there are many asbestos mines in California that have been operated intermittently in the past only two of these are located in the bay region. One is in Napa County, about a mile west of the road between Napa and Monticello, and approximately 19 miles by road north of Napa. Mining operations began on this property in 1941 and ceased in 1945. In 1942 a 40 ton mill was installed at the mine. A considerable but unknown amount of short-fiber asbestos was produced and marketed under the trade name "Plastene" for use in fireproof plaster and succo construction. The other asbestos deposit in the bay region is located in Alameda County, near the Contra Costa County line in the hills east of Fruitvale. In 1915 a few tons of asbestos were mined here and ground for use with magnesite in the manufacture of fireproof tile.

Quicksilver occurs in the Franciscan in many of the bay counties and is mined whenever the price warrants operations. Although the quicksilver was introduced in the late Tertiary or even in the Pleistocene, it is frequently found in Franciscan rocks, especially on the contact with serpentine and other Franciscan rocks, and particularly on fault contacts. The minerals found are red cinnabar and black metacinnabar; the former is the most common. There are several mines in the Mount Diablo region in Contra Costa County, the largest being the Mount Diablo mine. This is on the northeast side of Mount Diablo near the piercement fault contact between Franciscan and Lower Cretaceous rocks. This mine is only a short distance from the Marsh Creek Road. There are many other quicksilver mines in the bay counties.

Oil usually is regarded as entirely foreign to the Franciscan formation and when wells drilling for oil encounter Franciscan rocks they are as rule quickly abandoned. In fact, oil geologists nearly always cease mapping when Franciscan contact is reached. However, the first oil wells drilled in California that actually found oil started and finished in the Franciscan. A well drilled in 1863 or 1864 in the Petrolia district in Humboldt County obtained a very small quantity of high gravity oil in the Franciscan. There are oil seepages from dark Franciscan shales along the coast north of the mouth of Bear River in Humboldt County. Wells west of Monticello in Napa County obtain small quantities of oil from the Knoxville. However, the production in all of these areas is not commercial, being measurable in gallons per week rather than in barrels per day. Although oil does occur in the Franciscan-Knoxville group, it has not yet been found in commercial quantities.

DIABLAN OROGENY

At or near the end of the Jurassic there was a period of uplift and disturbance called the Diablan orogeny. Although this disturbance resulted in the uplift of the western margin of the geosyncline in which the Franciscan-Knoxville rocks are found, the trough was not destroyed and sedimentation continued without interruption. The beginning of the Lower Cretaceous was marked by coarsening of the sediments in the trough. The base of the Lower Cretaceous is in most places marked by a basal conglomerate which ranges from a few feet to several hundred feet in thickness and contains debris of both Franciscan and Knoxville. In the region between the Sacramento Valley and the main Coast Ranges there is no angular discordance between the Lower Cretaceous and the Franciscan-Knoxville, but the contact is marked by a coarsening of the sediments and the appearance of pebbles and boulders of the Franciscan-Knoxville rocks derived from the uplifed margin of the geosyncline. Another effect of the Diablan orogeny was an eastern shifting by the fact that the thickest sections of the Lower Cretaceous occur in the eastern foothills of the Coast Ranges not far west of the western edge of the Sacramento Valley.

The Diablan orogeny did not destroyor cause a withdrawal of the sea from the geosyncline in which the Franciscan-Knoxville group was deposited but it deposited it disturbed, uplifted, and exposed to erosion the western margin and shifted the axis slightly eastward.

II. GEOLOGICAL PROCESSES

In finding an explanation of the broader characteristics of the present landscape it is unnecessary to consider detailed events prior to the late Miocene or early Pliocene,* because these events are of secondary importance so far as the appearance of the present landscape is concerned. It is not meant, however, that pre-Miocene events have had no influences on the present landscape. On the contrary, the characteristics and relative positions imparted on the older rocks by folding and faulting prior to the late Miocene are responsible for much of the variety in topographic detail. Some formations, for example, are eroded to a rugged topography, whereas others are sculptured into well-rounded hills. Extensive resistant formations form the higher crests of the broader mountain ranges, and smaller resistant bodies, including the products of ancient volcanic activity, add additional ruggedness. These, however, are in general subordinate characteristics; the gross forms, the ranges and larger valleys, the upland surfaces and the intermontane basins, are primarily the result of relatively recent events.

(Throughout much of the interval from the Nevadan disturbance -- late Jurassic-- to the middle Miocene, a land mass lay some distance off the present coastline. Where the Coast Ranges now are, there was a coastal basin, periodically subject to relatively mild deformation by which it was divided into subordinate basins. The patterns of these subordinate basins changed to a greater or lesser extent with each episode of deformation. In these basins great thicknesses of sediment accumulated, either marine or continental, depending on the geography of the times; these sediments were largely derived from the immediately adjacent highlands.)

In the middle Miocene** after a time of widespread innundation, a pronounced mountain-building (Orogenic) movement took place, at which time much of the structural framework of the present Coast Ranges is believed to have been established. Although the present topography of the Coastal Ranges reflects to some extent the influence of the earlier periods of deformation, the general direction and localization of the ranges had their inception at this time. Later diastrophisms, culminating during the mid-Pliocene, followed these major trends. The relative stability which characterized the Pliocene, and made possible the development of the Pliocene Gradation plain, came to an abrupt end at the close of that epoch. At that time there began the final phase of what in the mid-Pleistocene, was to prove to be the most important mountain-building (Orogeny) since the late Jurassic disturbance.

In the end-Pliocene orogeny the entire Coast Ranges region was uplifted, and the sea receded from the interior, lingering only in coastal bays. The younger sediments of the region were intensely folded; locally the strata were completely overturned. Both normal and thrust folding were prevalent. In some areas, such as the Petaluma district, depressed, raised, and tilted fault blocks were created. In other areas, a reversal of movement took place along the older faults; blocks which had formerly been downdropped were now raised, and some which had earlier been raised were depressed.

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* See Time Chart - Section IV.
** 10 to 25 million years ago

Pressures were strong near the coast, weaker to the east. Complexities in the fold pattern resulted in part from the presence of "islands" of unyielding crystalline rocks against which the folds of weaker sediments were crushed and deflected.

The late Pliocene gradation plain was preserved in the area of older, more resistant rocks where these were not seriously warped or broken. Uplifted ranges were immediately attacked by erosion and coarse debris was deposited not only in the late Pliocene but in the early Pleistocene as well.

Paleozoic Era

There are no known rocks of the Paleozoic age in either the San Francisco Bay region, or in the central Coast Ranges, unless the basement complex might be in part, of lower Paleozoic age.

From all visible evidence, the central Coast Ranges, including the San Francisco Bay region, were a low land mass throughout the Paleozoic; whose duration is commonly estimated at over 300 million years; they formed the eastern edge of the ancient land mass of Cascadia that lay off the coast of California. The Paleozoic sea lapped against the low land mass from the east.

In the late Jurassic and all of the Cretaceous, a time interval of at least 50 million years, the Coastal Ranges, including the entire San Francisco Bay region except the eastern part of eastern Sacramento and San Joaquin Counties, was covered by a shallow sea. To the west, probably more than 10 miles off the present coast, lay a mountain range made up of old crystalline rocks.

See Appendix 1 & 2

III. DYNAMICS OF EARTH MOVEMENTS

The variety of topographic expression found in the different parts of the Coast Ranges has been attributed primarily to the variety of types of uplift to which the ranges have been subjected, and secondarily to differential erosion of diverse rocks and deposition have greatly obscured the original forms produced by the earth movements. Some of the ranges have been raised in horizontal position, some have been tilted, and others have simply been arched upward. True horsts (uplifted blocks bounded by faults) and simple warped blocks are the least common; tilt blocks are the most common. The majority of ranges are more complex, having been formed by combinations of movements. The fault pattern itself has strongly influenced the topography. Where the bounding faults are parallel and straight the ranges tend to be uniform in width and rectilinear. Where the limiting faults converge, diverge or branch, the breadth of the mountain blocks varies. Faulting has directly or indirectly played the dominant role in fashioning the present landscape.

Franciscan-Knoxville Group

The oldest rocks deposited in the geosyncline that occupied the site of the present Coast Ranges are appropriately known as Franciscan, from the excellent exposures found in the San Francisco peninsula. These rocks, which consist of a heterogeneous assemblage of sediments, contemporaneous volcanics, and intrusives, are all well exposed in the San Francisco Bay region, Contra Costa, Marin, Sonoma and Napa Counties.

Franciscan-Knoxville rocks have an outcrop area of approximately 14,000 square miles in the Coastal Ranges of California. Furthermore, they either crop out at the surface, or are known to underlie the surface rocks over an area of fully 30,000 square miles, or approximately one-fifth of the total area of the state. This is only a part of the area of the original basin in which these beds were deposited.

The oldest sediments deposited in the geosyncline that occupied the site of the present Coastal Ranges are the arkosic sandstones of the Franciscan that were chiefly derived from the land mass to the west. Because of the cold and rainy climatic conditions that existed in the high regions in the western range, mechanical rather than chemical decomposition of the old crystalline rocks predominated. Because of this the feldspars and other soluble minerals were not decomposed but were carried into the basin of deposition in a fresh condition. Thus the sandstones making up the lower part of the Franciscan contain an unusually large proportion of fresh feldspars and are called arkosic sandstones.

Widespread submarine volcanism began, and there were sea floor out-pourings of basic volcanics, chiefly pillow basalts. Submarine explosions also resulted in ejection of coarse to fine fragmental material which formed the beds of volcanic ash intermixed with varying amounts of normal sedimentary material; coarser volcanic detritus was laid down as volcanic breccia and aglomerate. Flow and fragmental volcanic rocks are commonly interbedded with sandstones and shales and also with rather distinctive siliceous chemically deposited sediments, the radiolarian cherts, which are common in the Franciscan. So constant is the association of the cherts with the volcanic rocks, particularly the pillow basalts, that the conclusion is inescapable that the volcanics were instrumental in contributing an unusual amount of silica to the sea water. Both iron and manganese also were contributed in local areas by the volcanics and these, having been added in colloidal form, occur in the cherts, which were originally colloidal also.

The cherts are always rhythmically bedded, the individual beds or lenses ranging from less than an inch to six inches in thickness and averaging between two and three inches. The individual chert lenses are separated by partings of shale that range from paper thinness to an inch in thickness.

There are considerable variations in color in the cherts, but the prevailing color is red; most of the thin shale partings have the same color as the chert. Although the prevailing color is deep red, the cherts may be white, pale pink, yellow brown, various shades of green, chocolate brown, and even black. The color depends largely on the state of oxidation of the iron and to a lesser extent on the presence of manganese.

The silica making up the cherts was originally colloidal, but because of the great depth of burial and the strong folding suffered by the Franciscan as a whole, the cherts have become crystalline and are largely made up of a fine mosaic of quartz or chalcedony, or both.

The volcanics, cherts and limestones are interbedded and occur with normal detrital sediments, such as sandstones, conglomerates, and shales. All were formed in shallow water in a slowly sinking basin.

Both the Franciscan and the Knoxville formations are extensively intruded by basic and ultrabasic igneous rocks. The ultrabasic rocks, peridotites and dunites made up of varying proportions of the heavy basic silicates olivine and pyroxene, have been completely or almost completely serpentinized. Large irregular areas of serpentine, with minor amounts of closely associated gabbro and diabase, are widely distributed throughout the Coastal Ranges. Some of these basic and ultrabasic intrusives locally metamorphosed the adjacent Franciscan sediments into glaucophane schists. These beautiful blue and green schists are especially well developed on the Tiburon peninsula, in the north Berkeley hills, and to the west of Healdsburg.

The total thickness of the Franciscan is not known as there are no continuous sections from the base to the top exposed anywhere in the state. In fact, the base of the Franciscan has never been found. This seemingly peculiar situation stems from the fact that the Coastal Ranges were strongly folded and faulted several times both in the late Mesozoic and in the Tertiary; all of the known contacts with older rocks are faults, and hence the basal portion of the Franciscan always is buried beneath the surface.

The thickest reported section of Franciscan rocks, including practically all of the recognized rock types, is in Alameda and Santa Clara Counties, in the northern part of the Mt. Hamilton Range, where the exposed thickness is estimated to be 12,000 feet. There are several continuously exposed sections 10,000 feet thick along the east side of the Diablo Range. All of these are only partial sections, neither the top nor the bottom being exposed. It is estimated that the total thickness of the Franciscan is not less than 20,000 feet.

The Franciscan nearly everywhere is strongly folded and faulted, and most of the stratified rocks stand at high angles. As the land was reduced in elevation, the streams became more sluggish and erosion less rapid; chemical decomposition increased and silts and clays became more abundant. Therefore, in the upper part of the Franciscan and in the Knoxville stage, fine-grained clastic sediments predominate over coarse sediments.

The Knoxville stage of the Franciscan-Knoxville group is chiefly made up of dark, silty, clay shales with thin interbeds of fine-grained sandstone. The Knoxville sandstones are also arkosic, containing much unweathered feldspar, but they are finer grained and in general contain a greater proportion of silt and clay than the Franciscan sandstones. The dark clay shale of the Knoxville are identical with those in the Franciscan; conglomerates occur in the Knoxville but they are not abundant.

See Appendix 6

IV. GEOCHRONOLOGY

ERA	YEARS AGO	PERIOD	EPOCH	CHARACTERIZED BY
Archeozoic	5 billion to 1 billion 500 million	------	-----	earth crust formed; unicellular life
Proterozoic	1 billion 500 million to 600 million	------	-----	bacteria; algae
Paleozoic	600 million to 500 million	Cambrian	-----	marine invertebrates
	500 million to 440 million	Ordovician	-----	algae and seaweed
	440 million to 400 million	Silvrian	-----	air breathing animals
	400 million to 350 million	Devonian	-----	fish dominant; amphibians and ammonites
	350 million to 300 million	Missippian Carboniferous	-----	land area increase; development of winged insects
	300 million to 270 million	Pennsylvanian	-----	warm climates, swamps, reptiles
	270 million to 220 million	Permian	-----	many reptiles
Mesozoic	220 million to 180 million	Triassic	-----	volcanic activity, dinosaurs, reptiles
	180 million to 135 million	Jurassic	-----	dinosaurs, conifers
	135 million to 70 million	Cretaceous	-----	giant reptiles extinct, flowering plants, insects

ERA	YEARS AGO	PERIOD		EPOCH	CHARACTERIZED BY
Cenozoic	70 million to 60 million	Paleocene	Tertiary	Paleocene	advent of birds and mammals
	60 million to 40 million	Paleocene		Ecocene	modern mammals
	40 million to 25 million	Paleocene		Oligocene	sabertoothed cats
	25 million to 10 million	Neocene		Miocene	grazing mammals
	10 million to 1 million	Neocene		Pliocene	growth of mountains, cooling of climate, increase in grazing mammals
	1 million to 10,000	Quaternary		Pleistocene	glacier period
	10,000 to present	Quaternary		Recent	development of man

V.

ROCKS AND MINERALS

The three main classes of rocks:

Metamorphic: Metamorphic rocks are rocks which have been changed. Changes may be barely visible, or may be so great that is it impossible to determine what the original rock once was. All kinds of rocks can be metamorphosed -- sedimentary, igneous and other metamorphic rocks. Metamorphism results from heat, pressure or permeation by other substances.

Igneous: Igneous rocks are classified by their texture, mineral content, and origin. They all come from magmas -- molten mixtures of minerals, often rich in gases found deep below the surface. If magmas cool beneath the surface they form intrusive rocks and develop typical structures that may later be exposed by erosion. Magmas reaching the surface from extrusive rocks, such as the spectacular volcanic rocks.

Sedimentary: Sedimentary rocks are extremely varied, differing widely in texture, color and composition. Nearly all are made of materials that have been moved from a place of origin to a new place of deposition. The distance moved may be a few feet or thousands of miles. Running water, wind, waves, currents, ice and gravity move materials on the surface of the earth by action that takes pace only on or very near the surface. In total, these rocks cover about three-fourths of the earth's surface. Rocks are made up of grains or particles are called clastic; they may range from less than a thousandth of an inch to huge boulders. Other sedimentary rocks are of chemical or organic origin. Most sedimentary rocks form in layers or strata.

Chert: (sedimentary) flinty quartz-like rock, dull in appearance. Usually marine in origin. Red, green, gray; silica is the main constituent in form of chalcedony, opal and jasper. Formed by chemical precipitation from volcanic mineral waters.

Sandstone: Porous sedimentary rock, with a rough, gritty texture similar to sandpaper. Formed by layering.

Marine Alluvial Gravel: Sand, gravel or other sediment carried to its present location by a river, lake or sea at some previous time.

Soapstone: A soft rock with a soapy consistency, composed of much talc, with serpentine and carbonates, such as magnesite, dolomite or calcite.

Serpentine: Hydrous magnesium silicates. Parent materials: olivine, pyroxenes, and dolomite. Small masses of light colored talc are commonly found in most serpentine masses.

Jadetic Pyroxene: A tough translucent mineral member of the pyroxene group. White to deep green in color, used as a gemstone known as jade.

Feldspar: Any of a group of silicate minerals in igneous rocks. Most abundant of all minerals.

Talc: Number 1 in hardness scale. Color is yellow, green or gray. Feels greasy or soapy. Thick deposits are called soapstone.

HARDNESS: Hardness is used in a rough manner in mineral identification. There are much more precise ways of measuring hardness in industrial laboratories. Though arbitrary, Mohn's scale of 10 minerals is useful:

1. Talc
2. Gypsum
3. Calcite
4. Fluorite
5. Apatite
6. Orthoclase
7. Quartz
8. Topaz
9. Corundum
10. Diamond

Remember these ten by using the odd sentence "The Girls Can Flirt And Other Queer Things Can Do." Gypsum is harder than talc but not twice as hard; fluorite is harder than calcite and less hard than apatite. If an unknown will scratch all the minerals in the scale up to 4 and it is scratched by apatite, its hardness is between 4 and 5. Check carefully to be sure there is a distinct scratch. Don't test hardness on the face of a valuable crystal. For field use here are some other convenient standards of hardness:

2.5	Fingernail
3.0	Penny
5.0	Knifeblade
5.5	Window glass
6.5	Steel file

The term serpentine is loosely applied to any of several members of a group closely related, magnesium-rich minerals. It is also commonly used as a name for rocks composed predominantly of minerals and the serpentine rock group. Most serpentine rocks are alteration products of peridotites that originally were composed predominantly of silicate minerals rich in magnesium and iron, such as olivine and some pyroxenes. Under subsurface conditions not fully understood these hard silicate materials combined with water to form softer serpentine minerals of much different character. As peridotite rock bodies are almost always partly serpentinized, and as serpentine masses commonly include some unaltered peridotite, the terms serpentine and peridotite are sometimes used interchangeably.

Most land surfaces underlain by serpentine are distinctive. The rock tends to be full of cracks and commonly has little or no soil cover. Rain falling on these bare rock surfaces tends to sink quickly deep into the rock, leaving the surface dry. Serpentine terrains commonly are strewn either with blocks or scattered piles of blocks projecting through rust-colored or maroon-colored soil or with accumulations of shot-sized pellets of iron oxide. Tufts of grass and low bushes grow among the scattered blocks and a few trees are found at wide intervals. Because serpentine rocks are extensively fractured, landslides are common on the flanks of serpentine hills. Depressions in which water accumulates commonly develop behind these landslides. In arid regions bare hills of rusty red serpentine stand out prominently on the landscape and early settlers named many Red Mountains or Red Hills in various parts of the Coastal Ranges and Sierran foothills.

Peridotites, from which most Californian serpentines are derived, are medium- to coarse grained rocks consisting of various proportions of olivine and iron-magnesium-rich pyroxenes. The rocks are given varietal names according to the kind and abundance of minerals in them. A variety composed almost entirely of olivine is called dunite; one with more than 95% pyroxene is called pyroxenite. The most common variety in the bay counties contains large amounts of both olivine and the pyroxene enstatite, and is called saxonite. Although saxonite masses are most common, dunite and pyroxenite may occur anywhere within saxonite as irregular bodies; some of these are rudely layered. Dikelets of dunite and pyroxenite may cut the saxonite and each other as well.

Dunite rock surfaces tend to be smooth and even-grained, like a medium-grained sandstone, showing an occasional black grain of chromite or magnetite. Saxonite surfaces are similar except that they may be sparsely studded with one-eighth inch to one-fourth inch crystals of enstatite. Enstatite is recognized by its rectangular shape and by its conspicuous cleavages at right angles to each other. It flashes in the sun, and rock containing a large proportion of it sparkles like a cluster of rhinestones. In peridotites containing a large percentage of enstatite the crystals may be so large and numerous that the rock has an exceedingly rough surface.

Most freshly broken unaltered peridotite has a water-green or yellowish-green glassy appearance. If altered to serpentine, however, the freshly broken rock tends to be greenish-black in color and felt-like or sugary in texture. Even though altered, the enstatite crystals commonly retain their original form, and their softer alteration product, called bastite, looks much like the original pyroxene.

See Appendix 3 & 4

ROCKS AND MINERALS OF SOUTHERN ALAMEDA COUNTY

Calcite Dolomite	Mount Diablo Range, Arroyo Mocho-livermore/Pleasanton area.
Rhrodochrosite	Maganese-Carbonate, Arroyo MochoCorral Hollow Road between Livermore and Patterson.
Maganese	Minerals found in the Arroyo Mocho Ladd-Buckeye district or the Alameda-Stanislaus County line.
Chromite	Found with serpentine or peridotite. Usually found looking like leopard spots called leopard ore. During World War II it was mined in this area to supplement for the ore cut off due to the war. Found 15 miles southeast of Livermore in the Arroyo-Mocho. Del Valle Lake is 10 miles southeast and Mines Road will lead you there.
Gravel Beds	Deposited hundreds of thousands of years ago. Miocene stream gravel 10 million years plus.
Cretaceous Shale	Ridges around Walnut Creek and on the Altamount Pass east of Livermore show the fact that two thirds of the bay was once an ocean.

FIELD TRIP SUGGESTIONS

1. To see an outcrop of rock

2. To look at the rock exposed in a road cut

3. To quarries

4. To museums to look at rock specimen

5. To observe how rock is used in the community

6.
6. Vulcanism: Tilden Park (Tuff): traveling east from Oakland 1/4 to 1/2 mile from east end of Broadway Tunnel, Red face of road cut on left side of hillside.

APPENDIX 1

How sediments settle in water to form layers.

Reference 1, p. 58

APPENDIX 2

Crystallization of Alum solution.

Reference 1, p. 58

APPENDIX 3

Bake clay in the form of a brick to illustrate metamorphisms.

Reference 1, p. 94

APPENDIX 4

Prepare an exhibit to show differences between metamorphic rocks, igneous rocks and sedimentary rocks.

Reference 1, p. 94

APPENDIX 5

Normal and thrust faults in sand.

Reference 1, pp. 123-124

APPENDIX 6

EARTHQUAKE PATTERNS

PURPOSE: To show students that following earthquake activity over a long period of time they may be able to discover patterns of activity and possibly do some earthquake prediction.

PREPARATION: Obtain a Mercator World Map (Pacific centered)

EARTHQUAKE CONCEPTS:

1. The Richter scale measures the amount of energy released (Magnitude). Show how the Richter scale indicates an increase of about 10.4. Example an earthquake of 8.3 on the Richter scale (San Francisco earthquake 1906) which is 10,000 times that of one reading 4.3 on the Richter scale.
2. Intensity: based on actual observations of earthquakes. The Mercallic intensity scale is based on amounts from 1 to 12.
3. Earthquake areas can be lived in if proper building codes are enacted and enforced.
4. Earthquakes occur many times a day throughout the world
5. Earthquakes occur at different depths.
6. The epicenter is the location of the earthquake

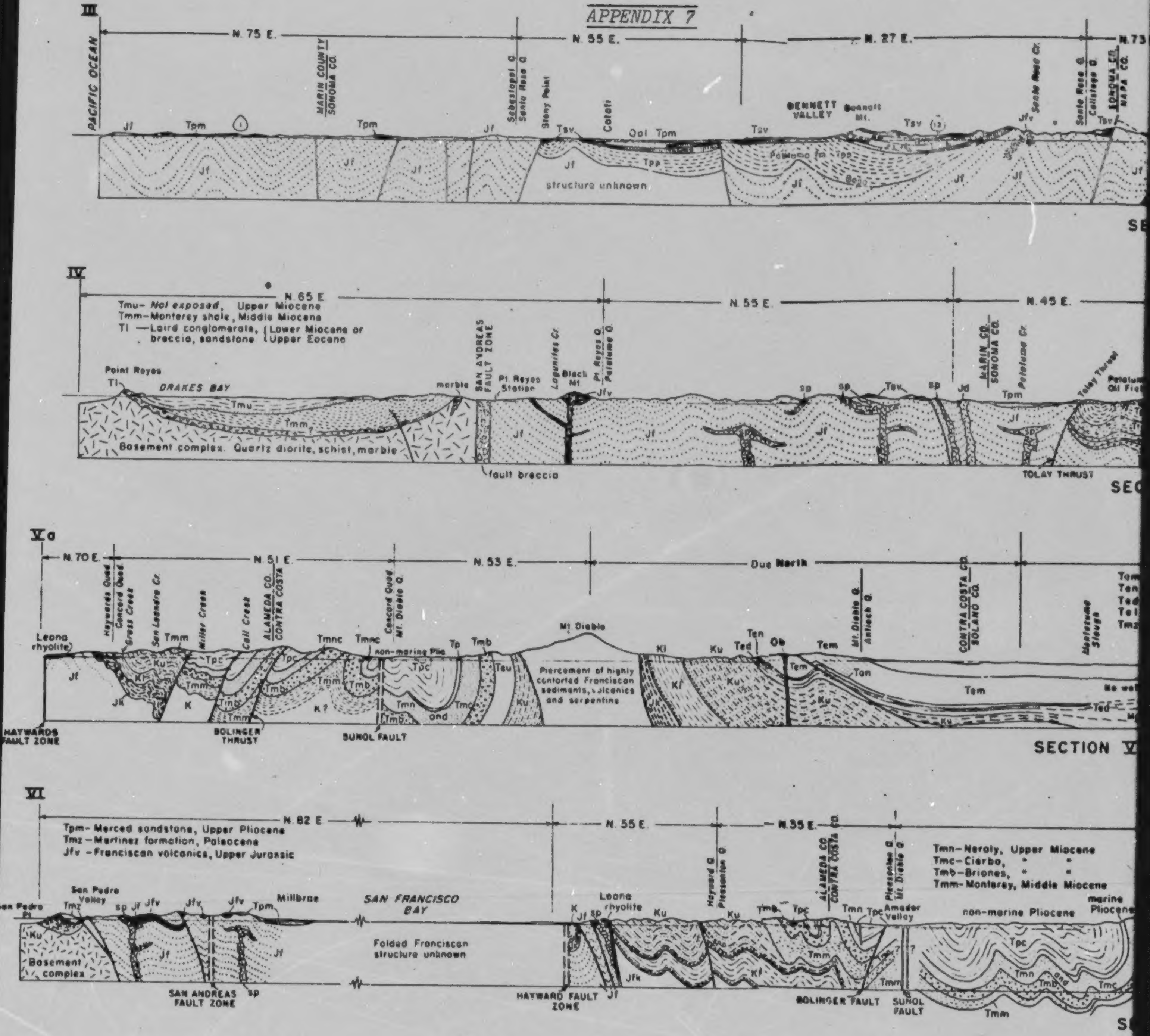
PROCEDURES: Plot earthquakes on your map using correct latitude and longitude figures. Use any method of plotting you and your students devise. Plot all earthquakes. This will graphically illustrate how many earthquakes there are throughout the world.

ORGANIZATION OF DATA:

1. Geographical occurance of earthquakes
2. Relationship of depth of earthquakes to the edges of continents
3. Relationship to volcanos, rift zones, and mountain building

NOTE: *Have students obtain information on major earthquakes which have occurred in the United States. Do this by readings: For example: Earthquake Country or The Late Great State of California.*

APPENDIX 7

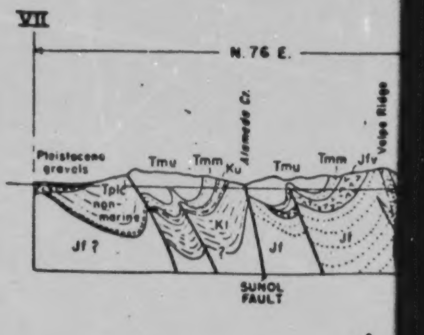

III
N. 75 E.
N. 55 E.
N. 27 E.
N.73
PACIFIC OCEAN
MARIN COUNTY
SONOMA CO.
Sebastopol Q.
Santa Rosa Q.
Stony Point
Cotati
BENNETT VALLEY
Bennett Mt.
Santa Rosa Cr.
Santa Rosa Q.
Calistoga Q.
SONOMA CO.
NAPA CO.
Jf
Tpm
Tsv
Qal
Tpp
Jfv
Petaluma fm – Tpp
structure unknown
SE
IV
N. 65 E.
N. 55 E.
N. 45 E.
Tmu– Not exposed, Upper Miocene
Tmm–Monterey shale, Middle Miocene
Tl —Laird conglomerate, breccia, sandstone { Lower Miocene or Upper Eocene
Point Reyes
DRAKES BAY
marble
SAN ANDREAS FAULT ZONE
Pt. Reyes Station
Lagunitas Cr.
Black Mt.
Pt. Reyes Q.
Petaluma Q.
MARIN CO.
SONOMA CO.
Petaluma Cr.
Tolay Thrust
Petaluma Oil Field
Tl
Tmu
Tmm
Jfv
sp
Tsv
Jd
Tpm
Basement complex. Quartz diorite, schist, marble
fault breccia
TOLAY THRUST
SEC
Va
N. 70 E.
N. 51 E.
N. 53 E.
Due North
Haywards Quad
Concord Quad
Grass Creek
San Leandro Cr.
Miller Creek
Cull Creek
ALAMEDA CO.
CONTRA COSTA
Concord Quad
Mt. Diablo Q.
Mt. Diablo
Mt. Diablo Q.
Antioch Q.
CONTRA COSTA CO.
SOLANO CO.
Montezuma Slough
Leona rhyolite
Tmm
Tmnc
Tp
Tmb
non-marine Plio
Tpc
Ku
Kf
Jf
K
K?
Teu
Tmn and Tmc
Piercement of highly contorted Franciscan sediments, volcanics and serpentine
Kl
Ted
Ten
Qb
Tem
Ku
Tom
Ten
Ted
Tel
Tmz
No wel
HAYWARDS FAULT ZONE
BOLINGER THRUST
SUNOL FAULT
SECTION V
VI
N. 82 E.
N. 55 E.
N. 35 E.
Tpm– Merced sandstone, Upper Pliocene
Tmz – Martinez formation, Paleocene
Jfv – Franciscan volcanics, Upper Jurassic
San Pedro Pt
San Pedro Valley
Tmz
sp
Jf
Jfv
Millbrae
SAN FRANCISCO BAY
Folded Franciscan structure unknown
Ku
Basement complex
SAN ANDREAS FAULT ZONE
K
Leona rhyolite
Hayward Q.
Pleasanton Q.
ALAMEDA CO.
CONTRA COSTA CO.
Pleasanton Q.
Mt. Diablo Q.
Amador Valley
Tmn–Neroly, Upper Miocene
Tmc–Cierbo, " "
Tmb–Briones, " "
Tmm–Monterey, Middle Miocene
non-marine Pliocene
marine Pliocene
Tpc
Tmn
Tmb
Tmc
Tmm
Jfk
Kf
HAYWARD FAULT ZONE
BOLINGER FAULT
SUNOL FAULT
SE

GEOLOGIC SECTIONS

ACROSS THE BAY AREA COUNTIES

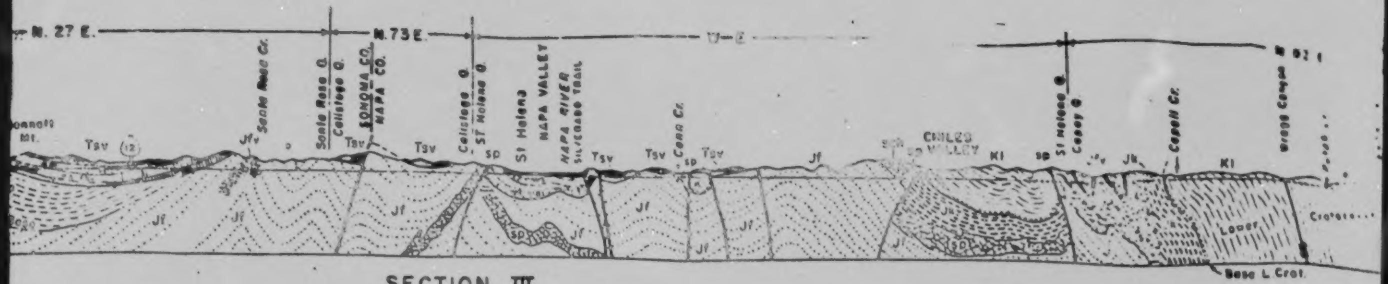
SHOWING SUB-SURFACE STRUCTURE

BY N. L. TALIAFERRO

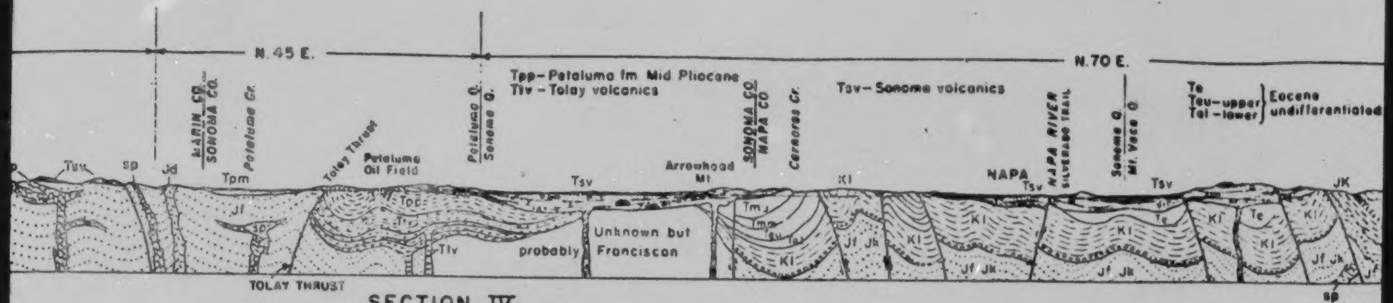

VII
N. 76 E.
Alameda Cr.
Volpe Ridge
Pleistocene gravels
Tplc non-marine
Tmu
Tmm
Ku
Kl
Jfv
Jf ?
Jf
SUNOL FAULT

0 1 2 3 4 5 6 7 8 9 10 MILES

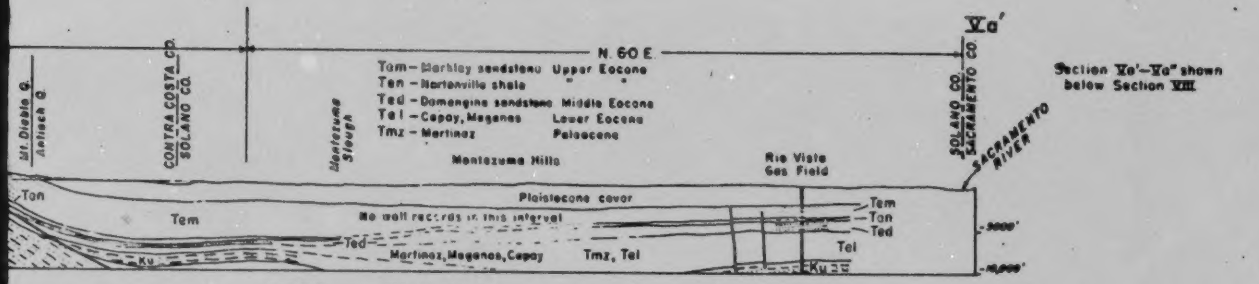
BEST COPY AVAILABLE


N. 27 E.
N. 73 E.
N. 92 E.
Donnell Mt.
Santa Rosa Cr.
Santa Rosa Q.
Calistoga Q.
SONOMA CO.
NAPA CO.
Calistoga Q.
ST Helena Q.
St Helena
NAPA VALLEY
NAPA RIVER
SILVERADO TRAIL
Conn Cr.
CHILES VALLEY
St Helena Q.
Capay Q.
Capell Cr.
Bragg Canyon
Tsv
Jfv
sp
Jf
Kl
Jk
Lower
Cretaceous
Base L. Cret.

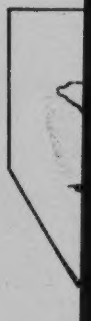
SECTION III

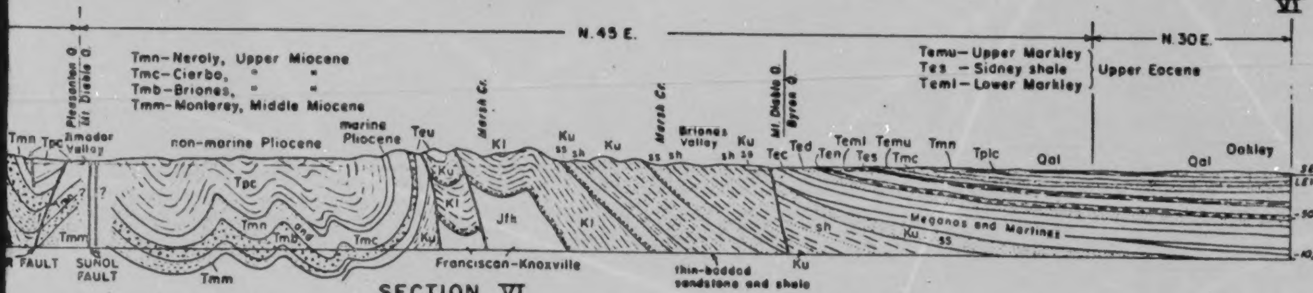

N. 45 E.
N. 70 E.
Tpp – Petaluma fm. Mid Pliocene
Tlv – Tolay volcanics
Tsv – Sonoma volcanics
Te
Teu – upper
Tel – lower
Eocene undifferentiated
MARIN CO.
SONOMA CO.
Petaluma Cr.
Petaluma Q.
Sonoma Q.
SONOMA CO.
NAPA CO.
Carneros Cr.
NAPA RIVER
SILVERADO TRAIL
Sonoma Q.
Mt. Vaca Q.
Tolay Thrust
Petaluma Oil Field
Arrowhead Mt.
NAPA
Tsv
sp
Jd
Tpm
Jf
Tpp
Tlv
Unknown but probably Franciscan
Tm
Kl
Te
Jf Jk
JK
TOLAY THRUST

SECTION IV

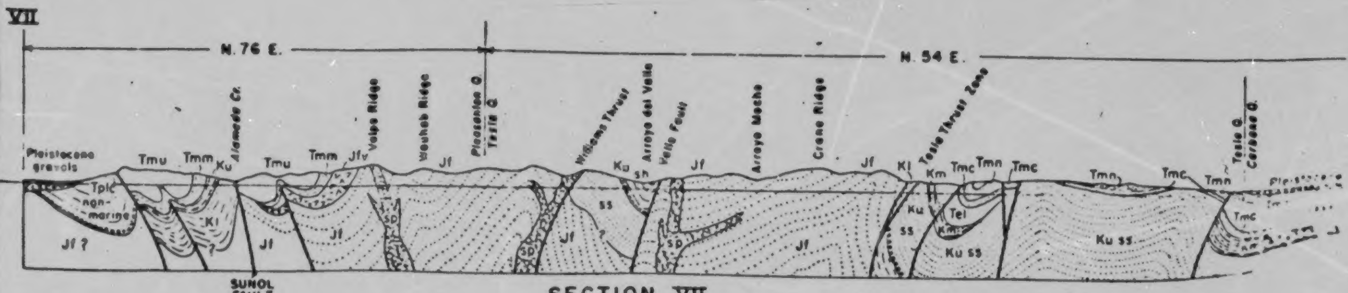

Va'
N. 60 E.
Tem – Markley sandstone Upper Eocene
Ten – Nortonville shale " "
Ted – Domengine sandstone Middle Eocene
Tel – Capay, Meganos Lower Eocene
Tmz – Martinez Paleocene
Mt. Diablo Q.
Antioch Q.
CONTRA COSTA CO.
SOLANO CO.
Montezuma Slough
Montezuma Hills
Rio Vista Gas Field
SOLANO CO.
SACRAMENTO CO.
SACRAMENTO RIVER
Section Va'–Va" shown below Section VIII
Pleistocene cover
No well records in this interval
Ton
Tem
Ted
Ku
Martinez, Meganos, Capay
Tmz, Tel
Tel
-5000'
-10,000'

SECTION Va—Va'




VI'
N. 45 E.
N. 30 E.
Tmn – Neroly, Upper Miocene
Tmc – Cierbo, " "
Tmb – Briones, " "
Tmm – Monterey, Middle Miocene
Temu – Upper Markley
Tes – Sidney shale
Teml – Lower Markley
Upper Eocene
Pleasanton Q.
Mt. Diablo Q.
Marsh Cr.
Marsh Cr.
Mt. Diablo Q.
Byron Q.
Tmn
Tpc
Amador Valley
non-marine Pliocene
marine Pliocene
Teu
Kl
Ku
ss
sh
Briones Valley
Tec
Ted
Ten
Teml
Tes
Temu
Tmc
Tmn
Tplc
Qal
Oakley
SEA LEVEL
-5000'
-10,000'
Tmm
Tmb
Jfk
Meganos and Martinez
FAULT
SUNOL FAULT
Franciscan-Knoxville
thin-bedded sandstone and shale

SECTION VI


VII
N. 76 E.
N. 54 E.
Alameda Cr.
Vallejo Ridge
Wauhab Ridge
Pleasanton Q.
Tesla Q.
Williams Thrust
Arroyo del Valle
Valle Fault
Arroyo Mocho
Crane Ridge
Tesla Thrust Zone
Tesla Q.
Carbona Q.
Pleistocene gravels
Tmu
Tmm
Ku
Jfv
Tplc
non-marine
Jf ?
Kl
Jf
sp
ss
sh
Km
Tmc
Tmn
Tel
Ku ss
Pleistocene
SUNOL FAULT

SECTION VII

N. 54 E.

GLOSSARY

ALLUVIAM	Unconsolidated stream deposits of mud, sand and gravel
BRECCIA	A rock composed of angular fragments commonly cemented together
DEPOSITION	Depositing of layers; that which is deposited, sediment
DIASTROPISMS	The profound process by which the earth's crust is deformed
EPOCH	One of the divisions of geologic time. Any event or time of an event marking the beginning of a relatively new development or developments
FAULTS	Earth fractures or zone of fractures along which the rocks of one bounding wall have been displaced.
FRANCISCAN-KNOXVILLE	The oldest rocks deposited in the present Coast Range; from Santa Barbara to Oregon
OROGENY	Pronounced mountain building
PALEONTOLOGIST	A scientist who deals with the life of past geological periods
STRATA	Sheetlike mass of sedimentary rock or earth of one kind, usually in layers between beds of other kinds
TOPOGRAPHY	The art or practice of graphic and exact deliniation in minute detail, usually on maps or charts, of the physical features of any place or region; the configuration of a surface, including its relief, the position of its streams, lakes, roads cities, etc.

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3. Division of Mines, Geologic Guidebook of San Francisco Bay Counties, Bulletin 154, San Francisco, 1951
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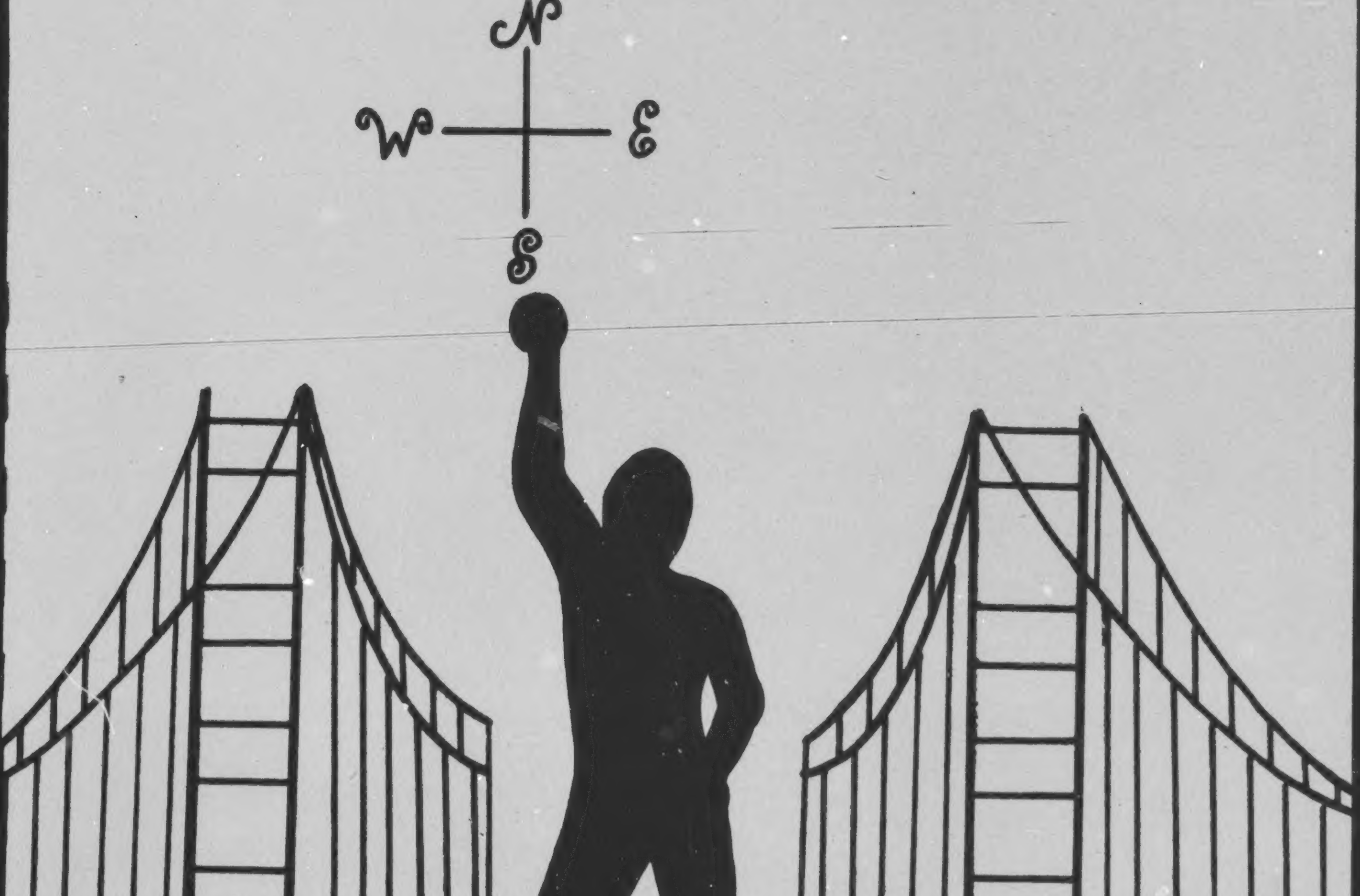
geography of the S.F. bay delta region



INTRODUCTION

A map is a model of the physical features of an area, changing the actual dimensions into abstract representation on a plane. Students need a comprehensive understanding of how a map is made and how to read symbols for distance, direction, landmarks and topography. The relationship of different land forms to one another is demonstrated by map study, investigations and actual observation of the terrain from as high a point as possible. Changes in topography can be traced on maps of the same area at different periods of time. The effect of man on the landscape and environment are evident from maps, and from collections of data. Field trips to a region reorganize perceptions from symbols to actualities.

The activities are centered about two types of areas, (1) using maps of various kinds in the classroom; and (2) working outside, around the school, student's neighborhood and greater surrounding region.

This unit will cover the history of maps, kinds of maps and how to read them, how maps are made and how man has changed the land and water areas affecting the changing map outline. It will include an overview study of the San Francisco Bay Delta region topography andthe problems of this area.

The use of activities by a teacher would depend on the learning grade level of the class, time involved, curriculum emphasis, location of the school, administration cooperation and previous experience of the students. In some districts or schools, the social studies classes spend much time on maps and it might be wise to check if this is so.

Texts, references, materials and suggested evaluation are included in the activities or teacher suggestions. Several activities are specific to one area. However, they could be adapted to other places in Contra Costa and Alameda Counties. An expanded annotated reference list is contained at the end.

Since classes vary, evaluation is suggested but not specified.

GEOGRAPHY OF THE S.F.BAY-DELTA REGION

MAJOR OBJECTIVES:

After completing this unit, the student should be able to:

I. Locate a designated area or specific place on a map

II. Identify a given list of map symbols

III. Read an elevation on a topographic map using contour lines

IV. Describe characteristics of a given spot or area by reading contour lines

V. Calculate distances by use of map scale

VI. Demonstrate direction by reading a compass

VII. Explain how contour lines are made

VIII. Recognize topographical features in the field

IX. Relate topographical features and the effect of man on the environment

X. Explain the changes in the bay region by comparing maps of the present and past.

GEOGRAPHY OF THE SAN FRANCISCO BAY - DELTA REGION

I. MAPS AS MODELS

A. Maps give many kinds of information
Show a variety of maps, political, navigational, geological, weather and topographic of the earth and/or moon, as well as historical or special interest maps.
Discuss the purpose of maps. Ask students to describe maps known to them.

B. History of maps
Relate to the rise of civilization and scientific knowledge.
Have students and/or teacher present:

1. Oral or written reports on Mercator, John Smith, Champlain, Joliet, Ptolemy, Lewis and Clark, Captain Cook, Major Wesley Powell, I.G.Y.

   Reference 26- or any other encyclopedia available

2. A time line on the history of maps

   Reference 20, pp. 19-27

C. Reading a map

1. Symbols serve to condense information
Review use of symbols in our daily life. Show street and topographical maps with symbols

   Appendix 2

2. Scale explains how many miles there are in each inch of a map
Review how to read a standard foot ruler. Students practice by measuring parts of themselves and other objects in the room. For advanced students a comparison with the metric system could be used as an activity or discussion

   Equipment: Class set of standard foot rulers with inches on one side and metric scale on the other (optional)

3. Direction is indicated by position and compass
Show a simple compass. Discuss points of the compass including declination. Practice orientation with a compass
Students can work in pairs to check each other

   Equipment: Compasses

4. A city map helps us to find a particular place or route

   Appendix 1

5. A topographic map is a representation of selected man-made and natural features plotted to a definite scale
Explain use of these maps and show several to the class

   Reference 8, 29, 31, 32 & 37 Appendix 2

a) Symbols stand for landmarks
Show and explain the topographic map symbol sheet
Use maps to find some symbols

Reference 1, p. 31 *Appendix 2*

b) Contour lines show variation in elevation and slope

Reference 6 p. 131 *Appendix 3*
Reference 8 (1962) p. 373
Reference 8 (1965) p. 400
Reference 26

c) A topographic map gives descriptions of an area in three dimensions

Reference 8 (1962) p. 366 *Appendix 4*
Reference 8 (1965) p. 388
Reference 29
Reference 31

II. THE SAN FRANCISCO BAY AND DELTA REGION OVERVIEW

A. Topography of the Bay Area
Show local slides, if available and explain geographical features
Describe briefly the past geologic history of the area

Reference 9, 17, 21, 36 & 37

1. A locale map identifies landmarks

Appendix 5

2. A view from a high point shows landmarks and their relationships
Prepare for a field trip

Appendix 6

B. Changes in the Bay R

1. Human influence on the Bay and Delta regions
Present evidence and discuss relationship to fill, water diversion, population and pollution. Take field trips for visual confirmation

Reference 30 & 40 *Appendix 7*

Also contact: *Save the Bay Association*
Box 925, Berkeley, CA.
(pamphlets, leaflets, maps, displays)

S. F. Bay Conservation and Development Commission
30 Van Ness Ave., San Francisco, CA. 557-3686

2. Natural changes
Discuss earthquakes, floods, weather, wind, etc.

Reference 10 & 18

NOTE: *Other units of the guide*

APPENDIX 1

MY CITY AND THE AREA AROUND IT

MATERIALS:

A class set of city maps, two students to a map

Rulers and pencils

Two worksheets, 1A and 1B

Thin string for each student, 12 inches long

PROCEDURE:

1. Give out maps, rulers and worksheet 1A
2. Review with students how to read the ruler, miles, feet and how to figure distance. If the math to do this is too complicated, the string can be used and then measured.
3. Point out the legend, scale and compass rose, the numbered and lettered squares to be used in locating specific streets.
4. Explain worksheet procedure. Student who finishes 1A, goes on to 1B

BACKGROUND SUGGESTIONS:

City maps can be obtained from local gas stations, the Chamber of Commerce or AAA. The sample worksheet was developed for the El Cerrito-Richmond area but a similar one can be constructed for you particular situation. Note that part 1A is general, part 1B focuses on the relation of the student's home, school and area. Students may work in pairs of necessary. Check to see if the maps mark the school sites, since some do not.

Explain that to find a scale, one divides the size of an area by the size of the map. The answer would be the number of miles to the inch. The scale is shown in the legend as numbered intervals or verbally as one inch equals 1 mile. This idea may not be understood by some students.

EVALUATION:

Use the maps to construct a test, oral or written, to locate places, distances, landmarks.

Another way to evaluate would be to:

1. Give a starting point and ending point, The student is to give distance in miles and to list the streets from point to point.
2. Give a starting point and ending point. List distance in miles and all the landmarks (schools, parks, churches, etc) passed from point to point.

WORKSHEET 1A

APPENDIX 1

MY CITY AND THE AREA AROUND IT

Use the city map to find the answers to the following:

General Orientation:

1. In which city do you live? ____________________
2. What is the city north of your city? ____________________
3. What is the city south of your city? ____________________
4. Find Pinole. On which bay is Pinole? ____________________
5. Find Alameda. On which bay is Alameda? ____________________
6. Where does the highway go that runs to the top of the map? ____________
7. Where does the bridge lead to that starts at Richmond? ____________
8. Name two islands in the Bay: a) ____________, b) ____________
9. Name two large park areas east of Richmond and El Cerrito

   a) ____________, b) ____________

10. Name three points of land on the bay

    a) ____________, b) ____________, c) ____________

11. Name two yacht clubs a) ____________, b) ____________
12. Name three reservoirs

    a) ____________, b) ____________, c) ____________

The Symbols

1. Find one freeway, It is number ________
2. Find two main highways, Their numbers are ______ and ______
3. Find and name a one-way street ____________________
4. How can you tell where one city stops and another starts? ____________

   ____

5. What are gray circles? ____________________
6. Figure how far it is on Freeway 80 from Central to Hilltop ____________
7. How far is it from Moeser to Cutting along San Pablo Ave.? ____________
8. How far is it from Civic Center in Richmond to San Pablo? ____________

WORKSHEET 1B *APPENDIX 1*

MY CITY AND THE AREA AROUND IT

Use the city map to locate the following places:

1. On what street do you live? ____________________, City ____________________
2. What is the next nearest street? ____________________
3. How far is it to school? (use string or ruler) ____________________
4. Name a park near your house ____________________ How far is it? __________
5. Name one other park in your city ____________________
6. Where is the nearest hospital to your house? ____________________
7. Which high school is near your house? ____________________
8. On what street is the public library? ____________________
9. On what street is the City Hall? ____________________
10. Which street near your house is a main street? (notice that the lines are darker than the other streets) ____________________
11. List the streets you go on to get to Carlson Blvd, from your home

    ____
12. List the streets from your house to Freeway 80 ____________________

    ____
13. Describe the way to get to Alvarado Park or Jewel Lake or Tilden from your house

    ____
14. If you live at 35th and Barrett, what other street is it near? ____________________
15. What building is found at Ashbury and Eureka in El Cerrito? ____________________
16. What building is found at 23rd and Garvin in Richmond? ____________________
17. Where is the nearest BART station to your house? ____________________
18. Name the squares which locate the following streets

a) South 56th St.	__________	e) 40th Street	__________
b) Creely Ave. (Richmond)	__________	f) Francisco Way (E.C.)	__________
c) Canyon Trail (Park)	__________	g) Martin Luther King Park	__________
d) Douglas Drive(E.C.)	__________	h) Douglas Street (san Pablo)	__________

19. Suppose you were invited to a party on Garden Lane in El Sobrante. What streets would you drive on to get to the party from your house? ____________________

    ____

INFORMATION FROM TOPOGRAPHIC MAPS

MATERIALS: U.S. Geological Survey 7 1/2 minute quadrangle map of the student's area, one to every four students.

Topographic map symbol sheet, or teacher constructed sheet with limited number of symbols, class set, worksheet

PROCEDURE:

1. Point out the symbols are used in many areas, street, signs, lights, schools. Ask students for their knowledge of symbols.
2. Give out materials
3. Mention contour lines, though they are not used yet.

BACKGROUND SUGGESTIONS: The quadrangle maps cost 75¢ and can be purchased from Lucas Bookstore on Bancroft Way in Berkeley, or from the U. S. Geological Survey, 555 Battery Street, San Francisco, Ca. 94111, or sports shops in your area. Students who are Boy Scouts may have a contour map of the area.

EVALUATION: Test students on selected symbols

Have students write a picture story with symbols

WORKSHEET

APPENDIX 2

INFORMATION FROM TOPOGRAPHIC MAPS

The Richmond topographic map has streets on it like a round map but it has other symbols to give much information in a small space. Use the Richmond Quadrangle Topographic Map to locate the following places. Draw the symbol for each one. If you are not sure, check the map symbol sheet.

	Place	Location
1.	Portola Jr. High	Navellier and Moeser
2.	Church	6th and Bissell
3.	Tanks	Near Point Potrero
4.	Boundary	Between Richmond and El Cerrito
5.	Wooded Marsh	Along San Pablo Bay
6.	Scrub Brush	Below Madera School
7.	Railroad	Cutting and 4th
8.	Road	Central Avenue
9.	Road	Cutting Blvd.
10.	Mud	Richmond Inner Harbour

Look at the topographic map symbol list. Name and draw 4 you would not expect to find around your area

1.

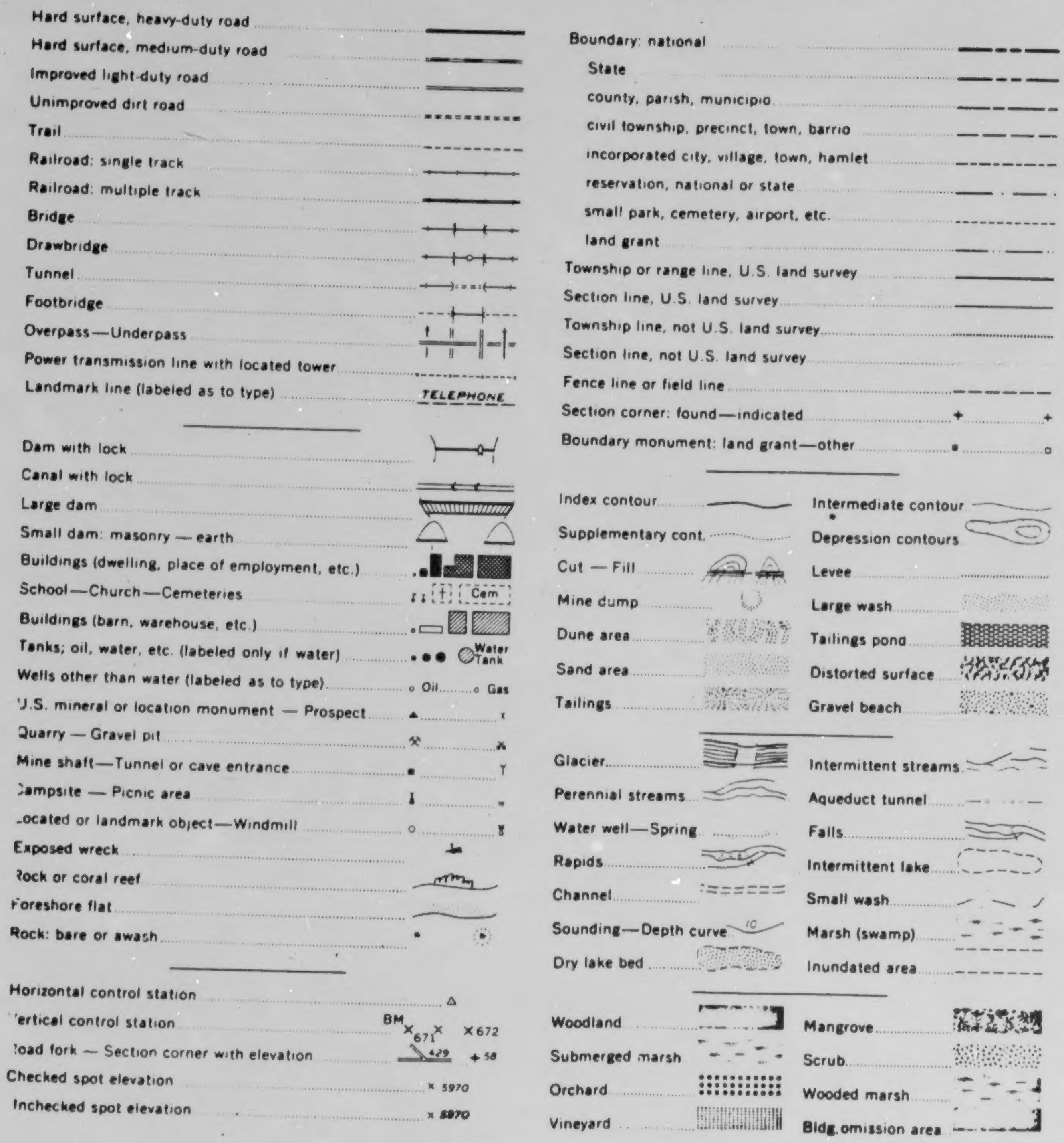
2.

3.

4.

TOPOGRAPHIC MAP SYMBOLS

VARIATIONS WILL BE FOUND ON OLDER MAPS



Hard surface, heavy-duty road
Hard surface, medium-duty road
Improved light-duty road
Unimproved dirt road
Trail
Railroad: single track
Railroad: multiple track
Bridge
Drawbridge
Tunnel
Footbridge
Overpass—Underpass
Power transmission line with located tower
Landmark line (labeled as to type) TELEPHONE

Dam with lock
Canal with lock
Large dam
Small dam: masonry — earth
Buildings (dwelling, place of employment, etc.)
School—Church—Cemeteries Cem
Buildings (barn, warehouse, etc.)
Tanks; oil, water, etc. (labeled only if water) Water Tank
Wells other than water (labeled as to type) Oil Gas
U.S. mineral or location monument — Prospect
Quarry — Gravel pit
Mine shaft—Tunnel or cave entrance
Campsite — Picnic area
Located or landmark object—Windmill
Exposed wreck
Rock or coral reef
Foreshore flat
Rock: bare or awash

Horizontal control station
Vertical control station BM × 671 × ×672
Road fork — Section corner with elevation 429 +58
Checked spot elevation × 5970
Unchecked spot elevation × 5970

Boundary: national
State
county, parish, municipio
civil township, precinct, town, barrio
incorporated city, village, town, hamlet
reservation, national or state
small park, cemetery, airport, etc.
land grant
Township or range line, U.S. land survey
Section line, U.S. land survey
Township line, not U.S. land survey
Section line, not U.S. land survey
Fence line or field line
Section corner: found—indicated
Boundary monument: land grant—other

Index contour
Supplementary cont.
Cut — Fill
Mine dump
Dune area
Sand area
Tailings
Intermediate contour
Depression contours
Levee
Large wash
Tailings pond
Distorted surface
Gravel beach

Glacier
Perennial streams
Water well—Spring
Rapids
Channel
Sounding—Depth curve 10
Dry lake bed
Intermittent streams
Aqueduct tunnel
Falls
Intermittent lake
Small wash
Marsh (swamp)
Inundated area

Woodland
Submerged marsh
Orchard
Vineyard
Mangrove
Scrub
Wooded marsh
Bldg. omission area

TOPOGRAPHIC MAPS AND CONTOUR LINES

MATERIALS:

Large piece of clay or plastic mountain model
Clear plastic shoe box with cover, approx. 12" x 6 1/2" x 3 1/4"
Water in jars or beakers
Food color
Metric ruler
Grease pencil
Sharp stick or pencil if clay is used
Clear plastic sheet or tracing paper, 6" x 12"

PROCEDURE:

1. Distribute materials with students working in pairs
2. Explain about using centimeters instead of inches, Presumably students have been exposed to this information already
3. Explain about drawing contour lines from the top. It is more accurate if you sight down the pencil or close one eye.
4. You may decide to have students do this with models of several shapes

BACKGROUND SUGGESTIONS:

A kit for this experiment is part of the ESCP geology program and consists of a rigid transparent plastic box with lid, a clear plastic sheet, molded mountain model of plastic. The cost is $2.00 for an individual kit, $24.00 for a set of 15 and can be secured from Hubbard Scientific Co. P. O. Box 105, Northbrook, Ill. 60062. However, one can purchase plastic shoe boxes, often on sale, at Long's or Payless or Woolworth for 39¢ to 59¢. The mountain may be modeled out of oil clay cutting down the cost of the total kit.

The food color is added to the water to see it better and is optional.

If the plastic mountain is used, students may need to tape it down, as it sometimes floats. Water base pens will not work on the plastic but waterproof grease marking pencils or crayons will. If clay is used, a sharp pencil or stick may be used to mark contour lines.

EVALUATION:

The answers to the questions on the sheet would indicate if the student understood the activity.

If photographs of an area are available, together with contour maps, a matching exercise might be developed.

WORKSHEET

APPENDIX 3

TOPOGRAPHIC MAPS AND CONTOUR LINES

Elevation or height on a topographic map is the distance above the sea level. Contour lines join points of equal elevation. The distance between contour lines on your map is 20 feet. The following investigation will help you discover how contour lines represent land surfaces.

MATERIALS:

Large piece of oil clay
Plastic shoe box with cover
Beaker of colored water
Metric ruler
Grease pencil
Sharp lead pencil
Clear plastic sheet or tracing paper

PROCEDURE:

1. Model mountain so that it has one steep side and one gently sloping side. It should fit the plastic box
2. With grease pencil and ruler, draw a line from top to bottom on one side. Mark a dot along this line every 1.5 cm.
3. Place model in the box. Pour colored water up to the first 1.5 cm mark
4. With sharp stick mark around the mountain. This is the first contour line.
5. Add water to the second mark. Draw around the mountain again
6. Continue to add water and draw lines until you reach the top
7. When you finish, put the lid on, tape on the tracing material. Trace the contour lines. Look directly down the tip of the pencil or close one eye.

QUESTIONS:

1. Are the lines close together or far apart if the slope is steep?
2. Are the lines close together of far apart if the slope is gentle?
3. How does your map of the model compare with a topographical map?
4. How would you show a crater in your mountain such as a volcano might have? (check symbol sheet)
5. Discuss: A map is a paper model of the real world

READING A TOPOGRPAHIC MAP

MATERIALS:

Topographic map symbol sheet
Any earth science book with topographic information
Worksheet
Topographic quadrangle map of the area

PROCEDURE:

1. Review contour intervals and any new symbols
2. Give out worksheet
3. Call attention to extra-credit work

BACKGROUND SUGGESTIONS:

This exercise focuses on direction, elevation and distance. Remind students the contour interval is 20 feet. The four activities at the end give challenge to the student who wishes to go further into the topic or is quicker than his classmates.

Students will need help with extra-credit No. 1. Geology and Earth Science Sourcebook has a discussion of this.

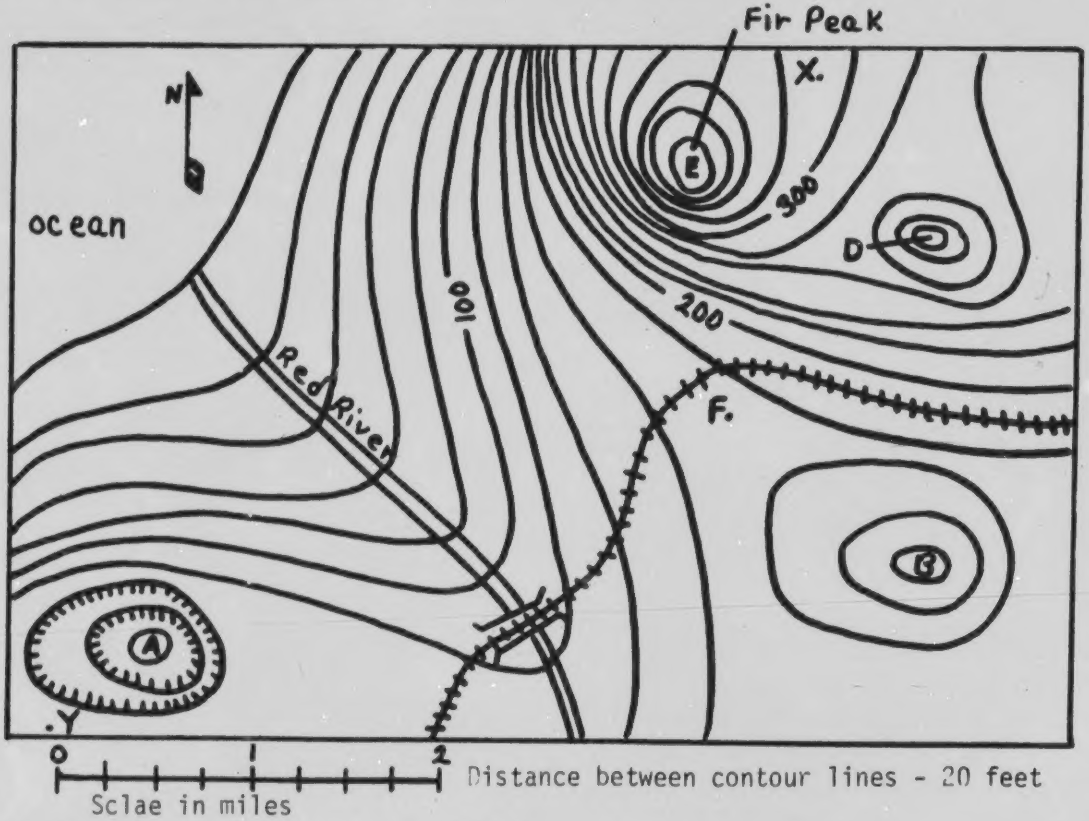
Stereo photographs are available from Hubbard (see address in Appendix 3) Book of Aerial Stereo Photographs, single copy $2.95. Also needed is a student stereoscope $1.95

EVALUATION:

Students might be asked to draw a section of a contour map similar to this one, make up questions and give the map to another student to analyze.

READING A TOPOGRAPHIC MAP

Refer to your topographic symbol sheet for this activity when necessary. The answers to the questions will be found in the map below.



Distance between contour lines - 20 feet

1. What is meant by a contour line? ______________________________

____

2. What is the elevation of the highest point on this map? ____________
3. What is the elevation at the closest contour line to the bridge ____________
4. How many miles of railroad track are shown on this map? ____________
5. In what direction does the Red River flow? ______________________
6. Rivers usually empty into the ocean. What else tells you the direction the river flows? ______________________________
7. What is the maximum elevation at letter A? ______________________
8. What special feature occurs in the neighborhood of letter A? ____________

____

9. How can you tell which slope is steepest on the map? ____________________

____

10. On what side do you find the steepest slope of Fir Peak? ____________________

11. If you were going to climb to point D, what direction would you go to make the climb easiest? (assume no unusual terrain)? ____________________

____

12. What is the elevation at point F ? ____________________

13. What is the lowest elevation on the map? ____________________

14. Describe a hike from point A to point B. The railroad bridge allows foot travelers. There are boats for hire on Red River. ____________________

____

____

RESEARCH PROJECTS: (Extra Credit)

1. Draw a cross section of the map from point X to point Y
2. Use layers of cardboard to make a built-up model of the map for this activity.
3. Obtain a topographic quadrangle of your area. Make a report of some of the more interesting and not so obvious features.
4. Draw of model a cross-section across two points showing differing elevations as suggested by your teacher.
5. Draw a topographic map from some stereo photographs. Describe how the stereo feature makes the task easier.

GEOGRAPHIC FEATURES OF THE BAY REGION

MATERIALS: Lists and blank maps
Topographical maps of the Bay Region (see references)
Nautical maps pf the Bay Region (see references)
Geologic maps of the Bay Region

BACKGROUND SUGGESTIONS: Discuss physical features of the sites to be named.
Define terms such as peninsula and fault
Often outline maps may be found in school or district libraries. (One type is included here)

EVALUATION: Identification test and questions on topography

WORKSHEET

APPENDIX 5

GEOGRAPHIC FEATURES OF THE BAY REGION

Label the Bay Area map with the following names. Use a number key if you wish. Place a compass rose in the ocean to show direction.

Bridges:

1. Carquinez Bridge
2. Richmond-San Rafael Bridge
3. San Francisco Oakland Bay Bridge
4. San Mateo-Hayward Bridge
5. Dumbarton Bridge
6. Golden Gate Bridge
7. Benicia-Martinez Bridge
8. Antioch Bridge
9. Rio Vista Bridge

Cities and Towns

1. Antioch
2. Martinez
3. Vallejo
4. Crockett
5. Richmond
6. Albany
7. Berkeley
8. Oakland
9. Alameda
10. San Leandro
11. Hayward
12. San Jose
13. Redwood City
14. San Mateo
15. San Francisco
16. Sausalito
17. San Rafael
18. Pittsburg
19. Concord
20. Walnut Creek
21. Benicia
22. El Cerrito
23. San Lorenzo
24. Fremont

Waterways

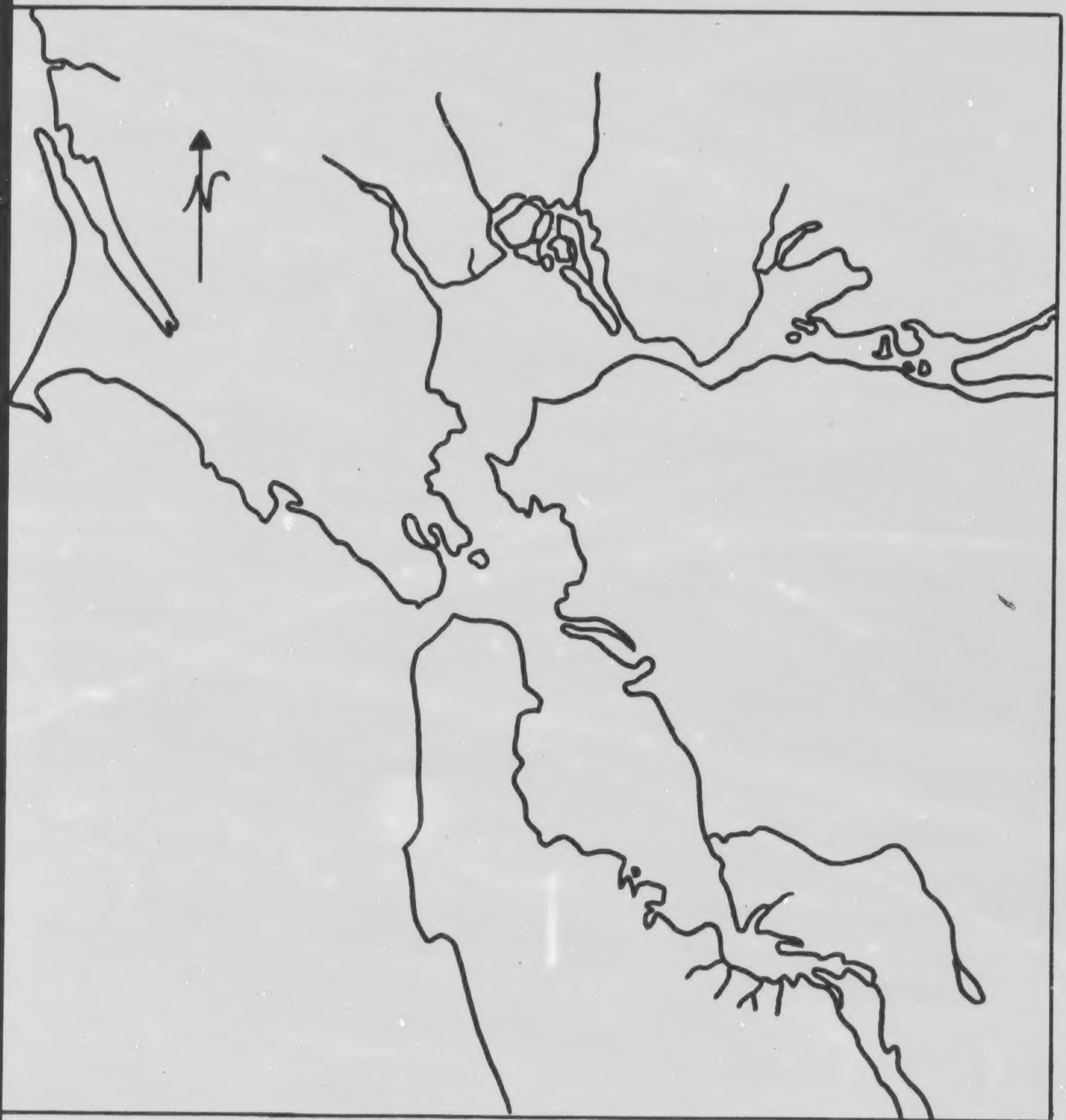
1. Sacramento River
2. Honker Bay
3. San Pablo Bay
4. San Joaquin River
5. Grizzly Bay
6. Napa River
7. Suisun Bay
8. Raccoon Straits
9. Carquinez Strait
10. Oakland Estuary
11. Coyote River

Geographical Landmarks

1. Chipps Island
2. Angles Island
3. Pt. San Pablo
4. Golden Gate
5. Dumbarton Point
6. Fort Point
7. Pt. Richmond
8. Hunter's Point
9. Pinole Point
10. Pt. San Quentin
11. Black Point
12. Mt. San Bruno
13. Mt. Diablo
14. Mt. Tamalpais

Geographical Points on the Pacific Ocean or outside the Bay

1. Tomales Bay
2. Duxbury Point
3. Pt. Bonita
4. Bolinas Bay
5. Half Moon Bay
6. Pt. Reyes National Seashore
7. San Pedro Point
8. Pacifica



San Francisco Bay Area

QUESTIONS:

1. Where are the marshy parts of the Bay Area? (be specific)
2. Where does fresh water enter the Bay?
3. Where are the two deepest parts of the Bay?
4. What mountains on the West influence the climate of the Bay Region?
5. What mountains in the East Bay influence the climate of the Bay?.
6. What is a peninsula?
7. Name four peninsulas in the Bay Region
8. Look at the fault map
    a) Where is the Hayward Fault?
    b) Where is the Andreas Fault?

A VIEW FROM THE TOP - FIELD TRIP

Find the highest point in your area for the class to view the surrounding region. Mt. Diablo is ideal, but not possible for many schools. Choose a hill, top story of a high building, or a bridge. The following questions are suggested for discussion and interaction at the site and back in the classroom.

1. What weather conditions do you see? Does it differ in any area?
2. Describe the scene, flat, hilly, sloping, angular
3. Name the features; creek, city, road, reservoir, river, faults, quarries, valleys, bay, islands, road cuts, etc.
4. Where is north, south, east and west?
5. What is man-made?
6. What is natural?
7. What vegetation do you see, what influences it, how does it differ in various areas?
8. What is highest point you see?
9. What is the lowest point?
10. Where are the recreational areas?
11. What waters drain into the bay, or where do creeks go?
12. How does the terrain influence the land?
13. Make a map of the area
14. Sketch the area and label
15. Relate topography to previous features studied.

FIELD TRIP

A field trip to the Bay and Delta Model in Sausalito is a valuable adjunct to the study of topography and the problems of the Bay. The model was built by the U.S. Army Corps of Engineers to test what would happen if barriers were established in the Bay. It is now used for a variety of water studies. The model extends to Sacramento and includes the proposed peripheral canal and the Delta Islands.

To plan a field trip, call 332-3870. Groups of up to 60 can be accommodated. The guided visit takes about 1 1/2 hours, Trained tour leaders explain the model, show slides and a film and walk the group through and around the model. A pamphlet is available for information. Students can take picture if they wish.

BAY AND DELTA MODEL, SAUSALITO

After the Field Trip is over, answer the following questions.
It would help to read them before the trip starts.

1. When was the original Bay Model built?
2. Why was it built?
3. How was the model built?
4. How was the information discovered about the Bay in order to make the model?
5. What is the purpose of the copper strips embedded in the Bay Model?
6. What tests are being made with the model now?
7. Where is the peripheral canal and what is supposed to be its purpose?
8. What do you think will be the effect on the Bay of the peripheral canal plan is carried out?
9. Summary: State in four or five sentences what you have learned about the Bay Area from visiting the Bay Model.

REFERENCES

Annotated References: this reference is divided into three parts: (1) student texts, (2) books, pamphlets and reports, (3) maps and lists of sources on mapping from the U.S. Geological Survey.

I. Student Texts

1. Bobrowsky Kenneth, The Air Above, The Ground Below, Scholastic Book Services, New York, 1971, pp. 73-77

   Paperback activities-oriented book with limited reading required, attractively presented. This is the earth science portion of one of four books. Teachers' Guide available.

2. Earth Science Curriculum Project, Investigating the Earth, Houghton, Mifflin Co. Boston, 1967 (revised 1972).

   Comprehensive earth science text. The revised edition is simpler in format than the original.

3. Environmental Studies Project, Environmental Studies Kit, 75 assignment cards AGI, Box 1559, Boulder, Co. 80302

   Imaginative activities which aid in the development of awareness to self and the environment by use if investigative strategies. There are several on mapping and area relationships. Price $20.00

4. Namowitz Samuel and Stone Donald, Earth Science, Van Nostrand Co. Princeton, N.J. 1965.

   Earth Science text with complete discussion of topography, Lab manual available: Activities in Earth Science, containing a series of topographic exercises.

5. Perkins. Otho, Earth and Space Science Skill Cards, Charles Merril Publishing Co., Columbus, OHio, 1968

   Boxed set of cards with individual or class projects in earth science, including topography.

6. Ramsey William, Burley Raymond & Phillips Clifford, Modern Earth Science, Holt, Rinehart & Winston, New York, 1969.

   Earth Science text for able readers, also lab manual: Activities for Modern Earth Science with three on topography.

7. Thurber Walter and Kilburn Robert, Exploring Earth Science, Allyn and Bacon, Inc. Boston, 1970.

   Easily read earth science text with pictures,diagrams and suggested investigations.

II. Books, Pamphlets and Reports

8. American Geological Institute, Geology and Earth Sciences Sourcebook for Elementary and Secondary schools, Holt, Rinehart and Winston, Inc. New York 1962 (revised 1970)

   Excellent source of information, resources and activities for earth science. In the 1962 edition, pp. 365-375 on topographic maps; pp. 377-391 on geologic maps. In the 1970 edition, pp. 387-405 on topographic maps; pp. 407-422 on geologic maps.

9. California Division of Mines Bulletin # 154, Geology of the San Francisco Bay Counties, 1951.

   Wealth of material, though dated, on the history, landscape, geology, fossils, minerals, industry and routes to travel in the Bay Counties. Can be purchased for a small amount from California Division of Mines and GEology office at the Ferry Building in San Francisco.

10. California Division of Mines and Geology, California Geology (formerly Mineral ~~Moneral~~ Information Bulletin), published mnothly.

    Pertinent articles including many on the Bay Area, book reviews, recent geologic events, film reviews. A bargain at $2.00 a year, but free to schools when requested on letterhead. Address: California Division of Mines and Geology, P. O. Box 2980, Sacramento, Ca. 95812.

11. Discus, Ninth Grade Earth Science

    Experimental curriculum from Florida with many clearly developed activities, Available at the Lawrence Hall of Science Library, University of California, Berkeley.

12. Durrenberger Robert, Patterns on the Land, National Press Books, Palo Alto, California, 1972, 4th edition.

    Geographical, historical and political maps of California, pictures, maps and data tables.

13. Earth Science Curriculum Project. Teachers' Guide to Investigating the Earth, Houghton-Mifflin Co. Boston, 1967, 2 volumes.

    Activities, suggestions, materials for all phases of earth science. Investigating maps as models, pp. 109-119.

14. Elementary Science Study, Mapping and Making Maps, McGraw-Hill, Novato, 1971, 2 booklets

    Teacher's directions on developing concepts of mapping and activities for this. Adopted for state science program.

15. Encyclopedia Britannica, Vol. 14, pp. 844-851 - Comprehensive history of maps.

16. Gross Phyllis and Railton Esther, Teaching Science in an Outdoor Environment, U. C. Press, Berkeley, Ca. 1972, pp. 147-151.

    Science activities keyed to the use of the U. C. natural history guides.

17. Howard, A.S. Evolution of the Landscape of the San Francisco Bay Region, University of California Press, Berkeley, 1967.

One of the natural science guides series. Brief presentation of complex subject.

18. Iacopi Robert, Earthquake Country, Lane Publishers, Menlo Park, Ca. 1971 (rev.)

Paper bound, popularly written, Many aerial photos and maps.

19. Jennings, J.H. Elementary Map Interpretations, Cambridge University Press 1963

Clear explanation of map reading. Used for English students who must pass geography examinations.

20. McFall, Christie, Maps Mean Adventure, Dodd, Mead & Co. 1961, pp. 19-27

Easy to read book with stories of map use.

21. Oakeshott Gordon, Geology of the California Coast Ranges, Mineral Information Bulletin, Vol. 23, No. 1, Jan. 1970, pp. 7-10, Calif. Div. of Mines and Geology.

Geology with aerial photos of the region. This issue also contains photos of different land forms in various places of the world.

22. Page, Ven M. Geology of Northern California, Calif. Div, of Mines and Geology, Bulletin 190, pp. 5-16

Another state-produced low-priced, complete history of the state's geology. Contains pictures and old maps.

23. Pestrong Ray, San Francisco Bay Tidelands, California Geology, Vol. 25, No. 2 Febr. 1972, pp. 27-40, Calif. Div. of Mines and Geology

Comprehensive article on tidelands in relation to fill, maps, charts, photographs.

24. San Francisco Bay Conservation and Development Commission, Geology of San Francisco Bay, Report, June 1966.

One of a group of published reports on the Bay. Discussion of geology and topography in relation to earthquakes, bay fill and water use.

25. Smith and Elliott, Illustrations of Contra Costa County, California, The Sacramento Lithograph Co. 1952.

Historical sketches and old photos of Contra Costa County. Available at University of California, Berkeley Geology Library.

26. Tannenbaum B. & Stellman M., Understanding Maps, McGraw-Hill Book Co. 1969.

Student reference, easy to read.

27. U.S. Geological Survey, Geological Maps-Portraits of the Earth, U.S. Government Printing Office, Washington D.C. pamphlet, 1968.

How maps are made, symbols, use of geologic maps.

28. U. S. Geological Survey, Motion Picture Film Services, U. S. Government Printing Office, Washington, D. C. pamphlet, 1972.

Lists geological survey films on geologic investigations, topographic mapping, water resources activities, astro-geological studies and aerial photo interpretation.

29. U. S. Geological Survey, Our Changing Continent, U. S. Government Printing Office, Washington, D.C., pamphlet, 1969.

The paleogeography of the North American continent with maps of it at different ages in times past.

30. U. S. Geological Survey, Program Design for San Francisco Regional Environment and Resources Planning Study. U. S. Geological Survey, 555 Battery Street, San Francisco, Ca. 94111, 1971. (free)

31. U. S. Geological Survey, Tools for Planning-Topographic Maps, U. S. Government Printing Office, Washington, D. C., pamphlet 1971.

What topographic maps are and who uses them and how they are used.

32. U. S. Geological Survey, Topographic Maps, U. S. Government Printing Office, Washington, D.C., pamphlet 1967.

Explains map scale, national topogrpahic map series, mapping procedures, and standards and symbols.

III. MAPS

33. California Geological Survey, 1871, Map of the Region Adjacent to the Bay of San Francisco.

Interesting old map of the area before 1900 with the old names, Baulines, (Bolinas), Saucelito (Sausalito), available at U.C. Berkeley Geology Library.

34. Plastic Relief Maps, Series V 502 P
    Sacramento NJ 10-6
    San Jose NJ 10-9
    Santa Rosa NJ 10-5
    San Francisco NJ 10-8

Formerly available from the Army Map Service, Corps of Engineers, U. S. Army. Now can be purchased exclusively from Hubbard Scientific Company, 2855 Shermer Road, Northbrook, Ill. 60062. Request copy of index map from them and ordering information. These are available at the U.C. Berkeley library map room and while not usually circulating, may be checked out by special request.

35. State of California, Department of Fish and Game, Ocean Fishing map of San Francisco, San Mateo and Santa Cruz Counties and Elkhorn Slough of Monterey County. The coastline and adjacent area. Available free from Dept. of Fish & Game, 1416 9th St., Sacramento, Ca. 95814

36. U. S. Board of Engineers, Port Series, No. 12, 1939. The Ports of San Francisco, Oakland, Alameda, Richmond and Upper San Francisco Bay, U.S. Government Printing Office, Washington D.C.

Aerial mosaic photographs of the area in the late 1930's. Good comparison with maps of today. Available at U.C. Berkeley Geology Library.

37. U. S. Geological Survey, Quadrangle Maps, 7.5 min series available for topography. List free from Geological Survey Office

Available from the U.S. Geological Office, San Francisco or Lucas Bookstore, Berkeley and from many sports and wilderness shops, Price $.75.

38. U. S. Geological Survey, Orthophotoquad Maps, equivalent to Quadrangle maps in 5, 7.5 min. topographic areas 1:24,000.

Order from Topological Division, Map Sales, U. S. Geological Survey, 345 Middlefield Road, Menlo Park, Ca. 94025. Price: approx $4.50. These can be seen at the U.C. Berkeley library map room and possibly borrowed from them.

39. U. S. Geological Survey, Map of the San Francisco Bay Region in 3 sheets covering approximately 3,000 square miles, scale: 1:125,000. Available in three forms:

> Topographic maps and slope maps, both available from U.S. Geologic Survey Office, 555 Battery Street, San Francisco, under $2.00 per sheet. Orthomosaic map available from U.S. Geological Survey Office, Menlo Park approx. $11.50 a sheet.

40. U.S. Geological Survey, San Francisco Bay Region Environment and Resources Planning STudy. 57 maps of different phases of bay planning. U.S. Geological Survey, San Francisco, maps are free.

41. U.S. Bureau of Land Management, Public Lands Guide Maps.

Gives recreational areas, also contours, State divided into 24 sections. Request free from Bureau of Land Management, Calif. State Office, 2800 Cottage Way, Sacramento, CA. 95825

42. U.S. Pacific Coast Nautical Charts showing shoreline and surrounding land. Catalog available from U.S. Geological Survey, S. F. Maps may be purchased from them, often found at sports shops in boating areas.

43. U. S. Geological Survey, Selected Bibliography on Maps and Mapping, U. S. Government Printing Office, Washington, D.C. pamphlet, 1971

Lists selected books about maps by title, author, publisher and date of publication. Provides information for teachers and students.

weather climate

INTRODUCTION

CLIMATE is a collection of weather records of an area over a long period of time. The atmosphere, position of the earth in relation to the sun, solar radiation and the geography of land masses are factors that determine world weather. These worldwide weather patterns, in turn, have great influence on our local climate. We have come a long way since the stories and myths from ancient Greece and Rome that told of the different gods of thunder, rain and wind. It is hoped that this study will develop some appreciation for the role of weather as it affects the organisms that inhabit our coastal area.

Scientists now have many scientific instruments to make accurate observations of our atmosphere and other conditions that make up weather. History would not be the same had some of these instruments been available in the very early days. We have many more observations from parts of the world that are either uninhabited or very sparsely inhabited or perhaps underdeveloped. Weather satellites, weather balloons, computers, and communication satellites from a worldwide network which help to make possible fairly accurate forecasts. Perhaps the most difficult area on the weather map is the San Francisco Bay Area. Our geography is unique. We have a sort of double line of mountains in the Coastal Range - the western most section including the Marin hills, and the Santa Cruz mountains, and the eastern most section which devides into the Berkeley Hills and to the south-east into the Diablo Range. Here the gigantic forces of continental air masses and oceanic air masses meet in constant battle. The Golden Gate is the largest gap or break in the Coastal Range thus creating very complicated weather patterns as is evidenced by the variety of Bay Area weather. This break continues through the Delta region to the Great Valley of California. These patterns are so varied that they often vary within a city. This unit is an attempt to encourage the student to understand the things that make up the weather, to try to note differences and keep records. Since our weather predictions are based on much information from the Weather Bureau in Washington, D.C. it would be difficult to try to predict weather in our schools with our very limited records. We will encourage the students to study the microclimates around their school. Keeping records and trying to interpret them should show how much our small area varies from day to day and yet how much it reflects the general patterns of the San Francisco Bay weather.

CLIMATE - WEATHER

MAJOR OBJECTIVES

Upon completion of this unit, the student will be able to:

I. Identify on a map factors which influence San Francisco Bay Area weather.

II. Identify the three major climatic zones on a map and discuss factors that contribute to this pattern.

III. Label the four air masses and explain which masses affect California weather.

IV. Name the weather conditions indicated on most weather maps.

V. Give definitions for a list of words commonly used in studying weather.

VI. Keep a daily record of microweather conditions at a class weather station.

WEATHER UNIT

I. BACKGROUND STUDY OF WEATHER

1. Early impact of weather on history

   Reference 7, pp. 107-111 *See Appendix 1*

2. The geography of the Bay as it relates to the fog and wind flow

   Reference 3 *See Appendix 2*

3. Cold water currents off the coast of California

   See Appendix 3

4. The large area of warm air called Pacific Highs

   See Appendix 4

5. The hills and mountains affect the rainfall and wind currents of the Bay region

   Reference 3, p. 50 *See Appendix 5*

6. Weather Vocabulary

   See Appendix 6 - Word List

II. FACTORS THAT AFFECT THE WEATHER

Reference 4

1. Temperature: Discuss the C and the F scale for measuring temperature

   Reference 1, pp. 181-192 *See Appendix 7*

   a) The effect of the earth's tilt on the heating of its surface

   See Appendix 8 & 9

   b) Warming of the air vs. warming of the water

   See Appendix 10

   c) The variation in temperature as we move away from the surface of the earth

   Reference 6, p. 1 *See Appendiz 11*

   d) Convection currents

   See Appendix 12

2. Pressure

   a) Causes of air pressure. How it drops with altitude and how it is measured

   Reference 5, pp. 11-12 *See Appendix 13 & 14*
   Reference 6, pp. 11-12
   (Use overhead projector to show aneroid and mercury barometers)

b) Air pressure is affected by temperature

Reference 1, pp. 192-207 *See Appendix 15 & 16*

c) Air moves from regions of high pressure to regions of low pressure

See Appendix 17

3. Humidity

a) The amount of water vapor in the air is humidity

Teacher should do several demonstrations such as having students breathe on a mirror, or soak a large sponge in water, squeeze out all of the water and then pour 1/4. 1/2 and finally all of the water back on the sponge.

b) Dew-point - the temperature at which condensation occurs as the air cools.

See Appendix 18

c) The causes of frost, sleet, hail and fog

See Appendix 19 - Discuss

III. WATER CYCLE

See Appendix 20 - Discuss

IV. WIND

1. Unequal heating of earth causes winds (general pattern is that it heats up more at the equator)
Discuss principle climate zones of the world and the relationship to wind belts

Reference 2, p. 437 *See Appendix 8 & 22*
Reference 5, chapter 15

2. Winds are deflected or change course due to the rotation of the earth on its axis.
Discuss the swirling of water down a drain
Have each student draw correolis effect by rotating a piece of paper clockwise as the student attempts to draw a straight line

3. Cold air is heavier than warm air and descends spinning clockwise because of the correolis effect. - Discuss winds

See Appendix 21a, 21b & 21c

4. Air moves from an area of high pressure to an area of low pressure belts forming the world wide system of winds of the earth
Use world map or globe to indicate where the belts of winds are found.

Reference 6 *See Appendix 21b & 22*

5. Winds are named for the direction they come from and a commonly used scale has been devised to indicate their relative speed

See Appendix 23 - Discuss
See Appendix 21a & 24 - Discuss

6. A wind vane indicates direction of the wind while an anenometer indicates how fast the wind is blowing

See Appendix 28

V. AIR MASSES AND FRONTS

1. Air masses are large amounts of air which have the same general temperature and same percentage of moisture. They tend to move as a mass and not mix with any other mass they might encounter. Show over-all map of the air masses in the Northern Hemisphere

Reference 2, p. 444 *See Appendix 25*

2. A front is the boundry between two airmasses

Reference 5, p. 364

a) A warm front is the boundry between a mass of cold air and an overtaking mass of warm air.
Discuss why a passing front means a change in weather

Reference 1, pp. 167-178 *See Appendix 11 - Discuss*

b) A cold front is formed when a cold air mass overtakes a warmer one.
Discuss why a front usually brings some form of precipitation
Discuss Cyclones, Tornados, Hurricanes and Thunderstorms.

c) An occluded front occurs when two cold fronts force a warm front to rise and stay suspended between the two cold fronts.
Discuss the factors that change as a front passes

d) A stationary front is the boundry between two air masses of like temperature - which is not moving.

3. Clouds are masses of water droplets or ice crystals suspended in the air

Reference 5, pp. 370-372 *See Appendix 26a & 26b*

VI. MICROCLIMATE

1. A basic weather pattern of any select region

Suggestions for discussion:
Where are the wind and fog gaps in our school grounds?
From what direction do the local winds blow and how fast?
Does precipitation vary from one site to another at our school?

Number and varieties of plants growing on school grounds
Size of plants
Make a comparison between school and home weather

70

VII. SETTING UP A WEATHER STATION

Discuss with the class the most appropriate location for a weather station. Class may be divided into groups and asked to make one of the following:

Raingauge
Hydrometer
Barometer
Windvane
Anenometer

See Appendix 27, 28, 29, 30, or any available instructions for simple weather instruments.
See Appendix 31 - Keep weather record for approx. one week.
See Appendix 32 - with key provided
See Appendix 33 - class activity or how to read a weather map.

The history of the world has been greatly affected by the whims of the weather. The history of the world is full of examples where the weather played a major role in the outcome of a battle. As early as 328 B. C., Alexander the Great attempted to stretch his conquest to India. Once he crossed the Indus River, the way was open for the conquest of India; unfortunately, his march was stopped by the heavy seasonal rains known as monsoons.

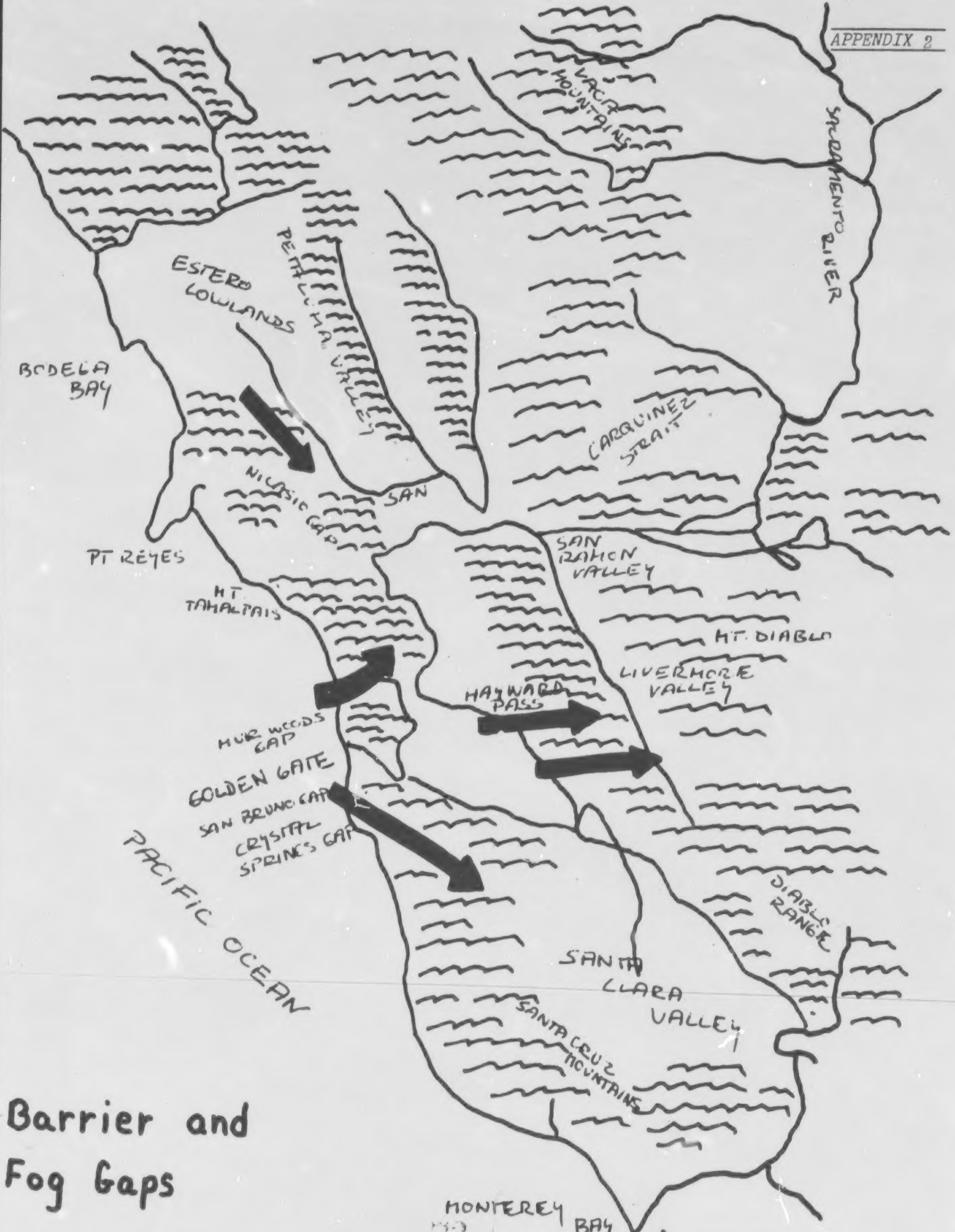
In the 13th century, Kublai Khan attempted to invade Japan. Although the Japanese fought valiantly they were on the verge of losing when a typhoon roared in and sank the Khan's forces. The name Kamikaze which means divine wind was given to the typhoon. The word kamikaze was also given to the suicide pilots of Japan during World War II.

George Washington took advantage of a sudden change in weather to achieve his objective. Trapped in Trenton because the roads were a mess of mud, he had almost given up hope when an unseasonable cold wind caused the roads to freeze. He marched his troops to Princeton and captured the garrison of British troops who were not expecting such an attack. The course of the revolutionary war was changed because of this battle.

Climate changes greatly aided the Russians in defending their homeland from invasion. Napoleon Bonaparte was defeated because his Army suffered from extreme heat during the summer and an unseasonable cold spell in October. During World War II, Hitler's weather forecasts indicated an ideal summer for his lightning quick raids. Unfortunately, he had not counted on strong opposition from the Russians and his attack took longer than expected. His troops were caught by the coldest Russian winter on record and his troops were almost wiped out.

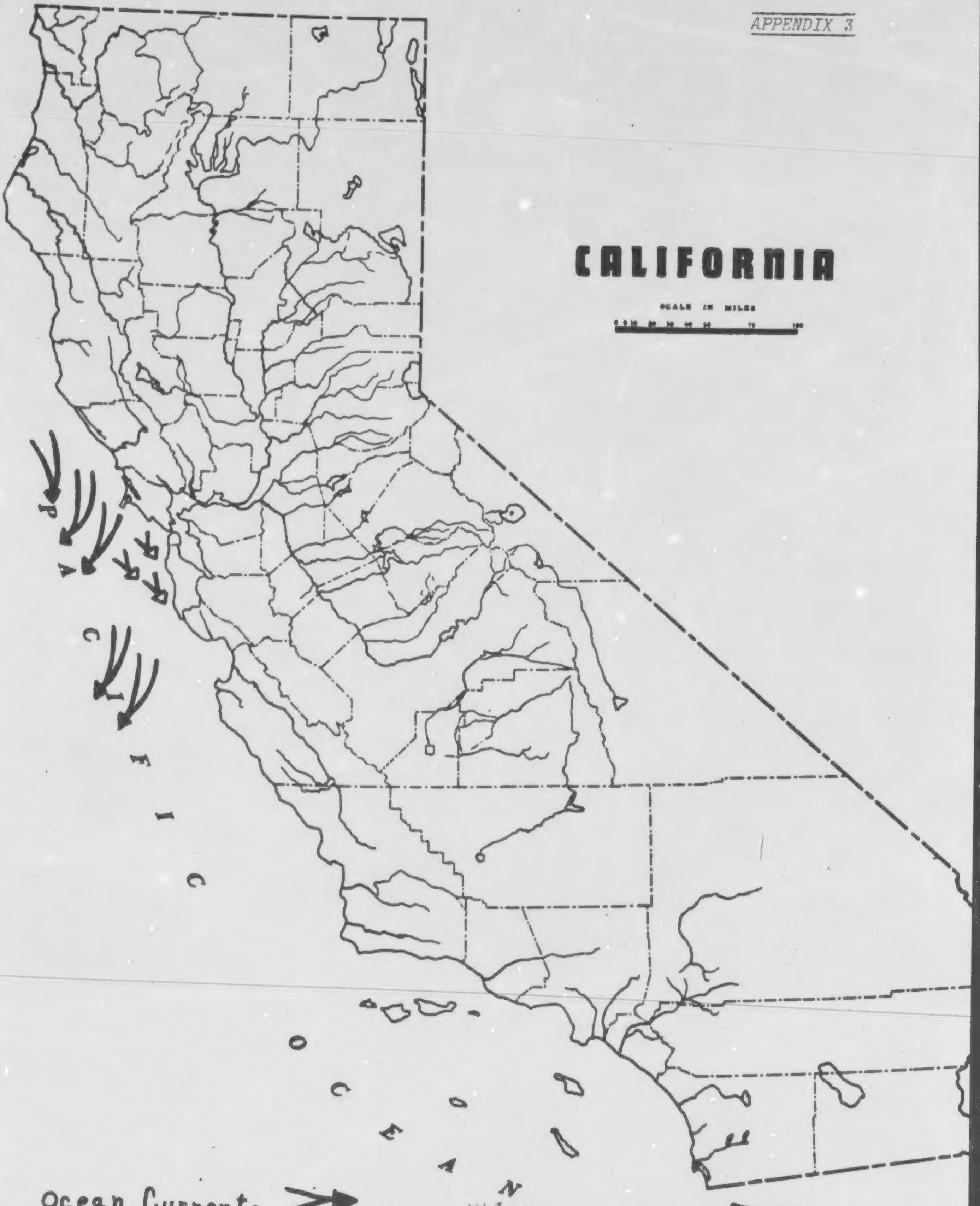
Because of the local fog, San Francisco was not discovered by Sir Francis Drake. It remained for the Spanish two centuries later to discover the Bay.

People are also affected by weather. In this area, the head-cold season occurs when there are drastic changes in the weather patterns, humid weather causes people to become more irritable and more likely to commit crimes than at other times.


VACA MOUNTAINS
SACRAMENTO RIVER
ESTERO LOWLANDS
PETALUMA VALLEY
BODEGA BAY
CARQUINEZ STRAIT
NICASIO GAP
SAN
PT REYES
SAN RAMON VALLEY
MT. TAMALPAIS
MT. DIABLO
LIVERMORE VALLEY
HAYWARD PASS
MUIR WOODS GAP
GOLDEN GATE
SAN BRUNO GAP
CRYSTAL SPRINGS GAP
PACIFIC OCEAN
DIABLO RANGE
SANTA CLARA VALLEY
SANTA CRUZ MOUNTAINS
MONTEREY BAY

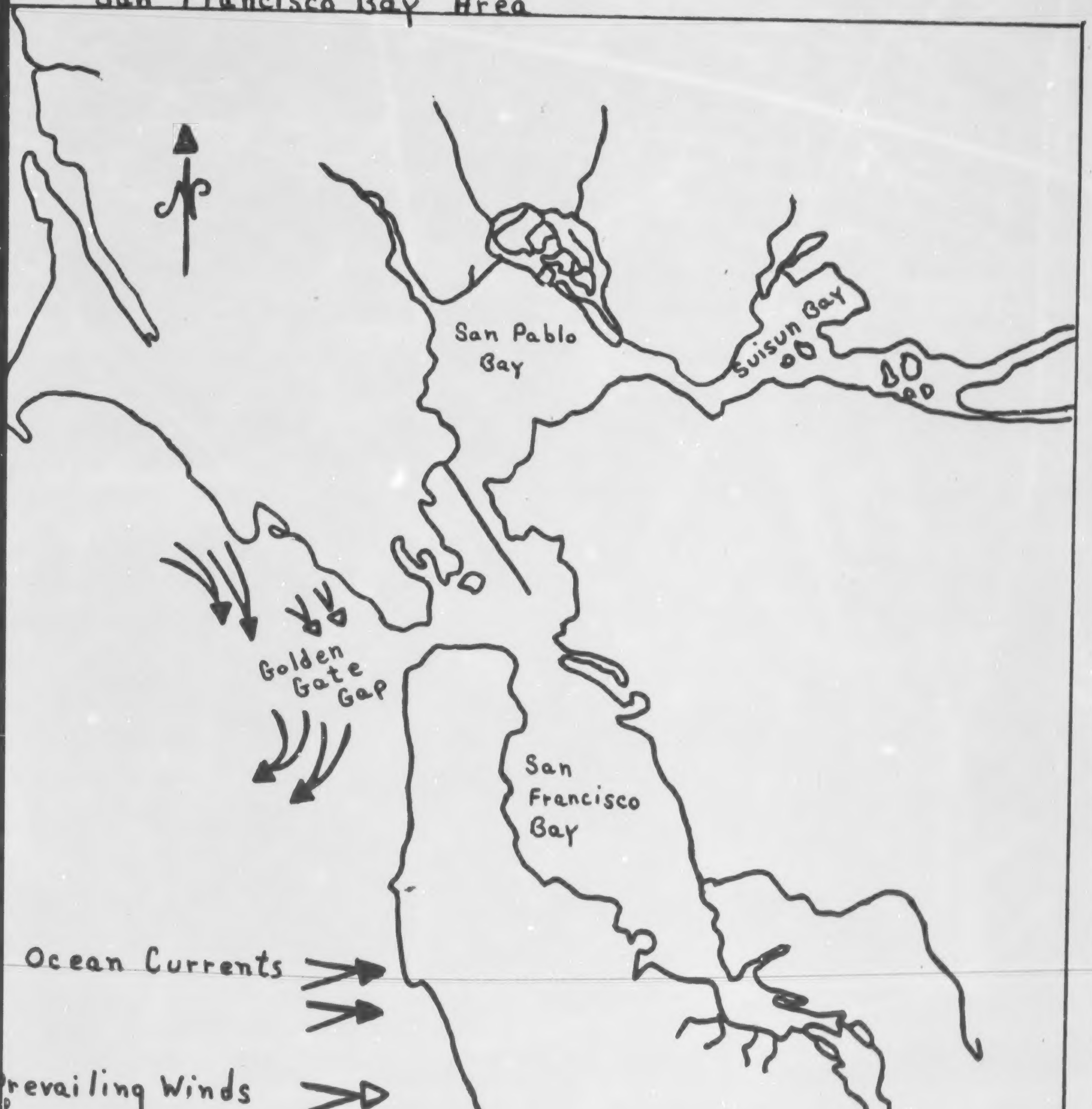
Barrier and Fog Gaps

APPENDIX 3

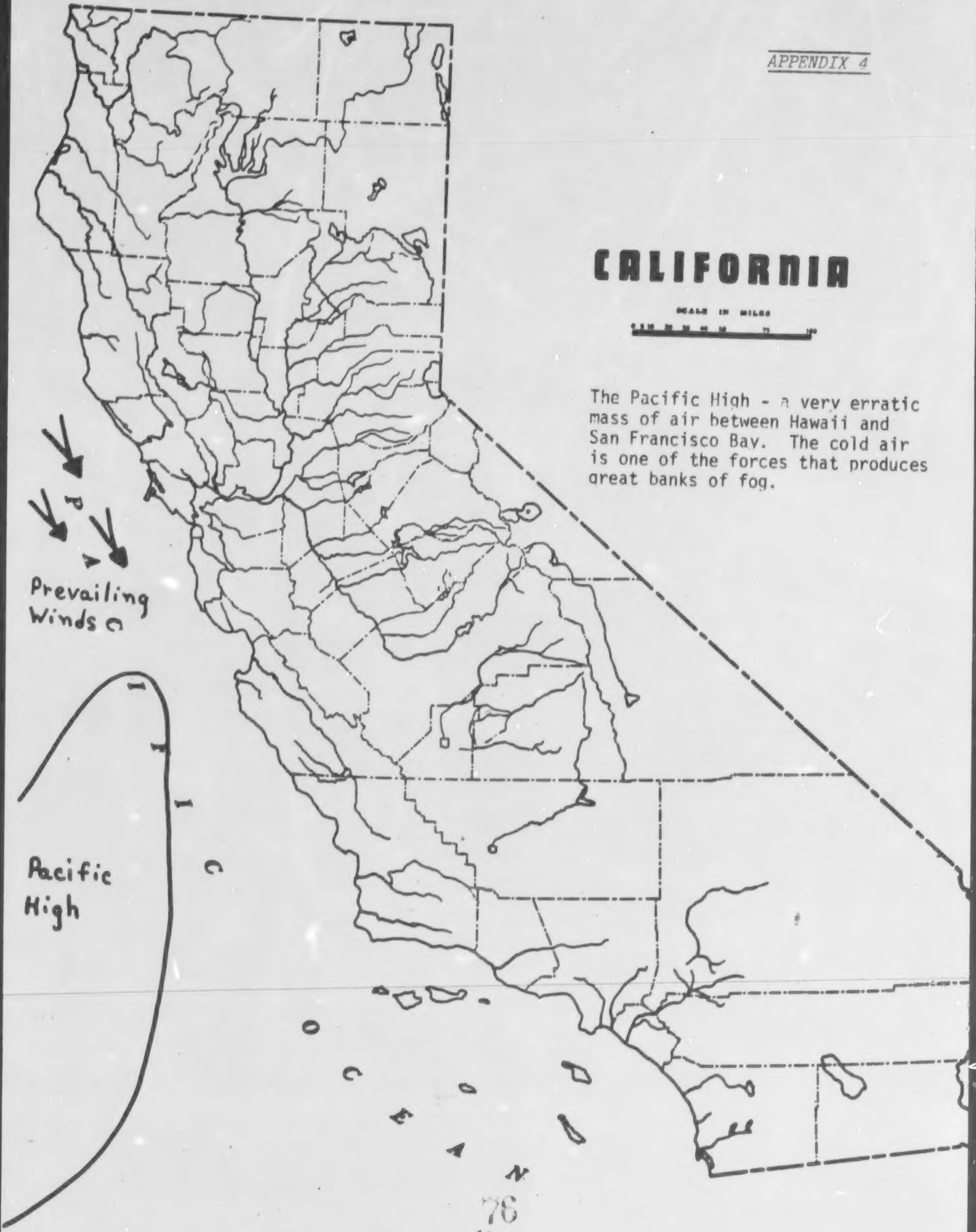

CALIFORNIA
SCALE IN MILES
0 5 10 20 30 40 50 75 100
P A C I F I C
O C E A N
Ocean Currents
Prevailing Winds

FINAL REVIEW TEST ON WEATHER FACTORS AFFECTING THE BAY AREA WEATHER

San Francisco Bay Area

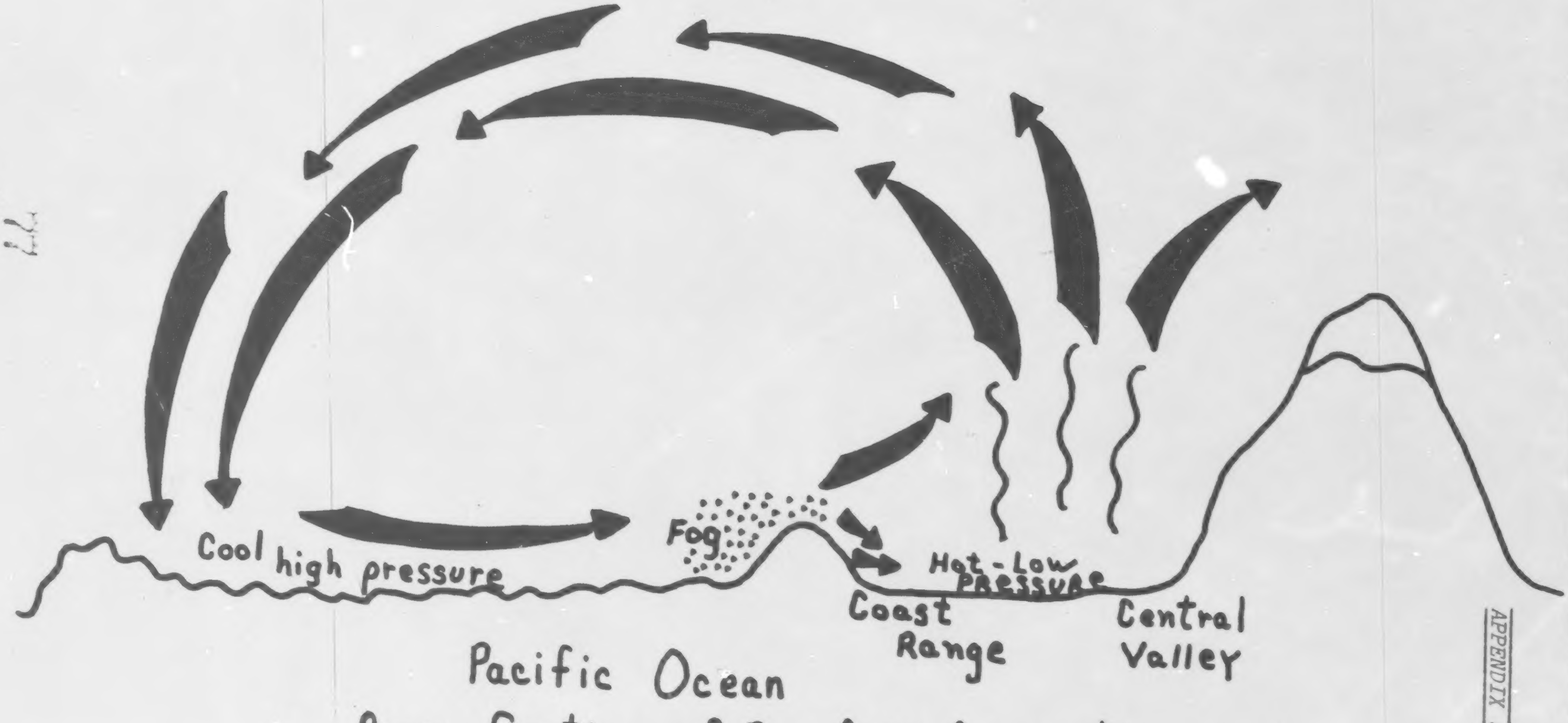

San Pablo Bay
Suisun Bay
Golden Gate Gap
San Francisco Bay
Ocean Currents
revailing Winds

APPENDIX 4


CALIFORNIA
SCALE IN MILES
Prevailing Winds
Pacific High
PACIFIC
OCEAN

The Pacific High - a very erratic mass of air between Hawaii and San Francisco Bay. The cold air is one of the forces that produces great banks of fog.

Weather Chart


Fog
Cool high pressure
Hot-Low PRESSURE
Coast Range
Central Valley
Pacific Ocean

Cross Section of Bay Area Convection Currents

WORD LIST

APPENDIX 6

AIR MASS	portion of air having the same characteristics such as humidity, temperature and density
ANENOMETER	an instrument used to measure wind speed
ANEROID BAROMETER	an instrument for measuring atmospheric pressure
ATMOSPHERE	envelope of air around the surface of the earth which can be as high as several hundred miles up
BAROMETER	an instrument to measure air pressure
CIRRUS CLOUDS	very high clouds made up of ice crystals
CLIMATES	average weather conditions over a long period of time
COLD FRONT	a boundary separating two masses of air, where cold air is replacing warm air
CONDENSATION	invisible water vapor changed into water
CUMULUS CLOUDS	thick cauliflower-like clouds of definite form with vertical development
CYCLONE	winds rotate in a counter-clockwise direction toward the center of low pressure
DEW	condensed water vapor on cooled surfaces
DOLDRUMS	the tropical belts of light winds and calms near the equator
FOG	tiny particles of condensed water vapor suspended in the air, a cloud near the ground
FRONT	the weather band located in the separation boundary between air masses
FROST	ice crystals which are deposited from the air on cool surfaces
HAIL	rain that has been carried aloft by vertical air currents and is frozen. It may repeat this process many times until it is too heavy to be supported by the air currents
HUMIDITY	the water vapor content in the air
HURRICANE	a violent tropical storm which forms over tropical waters. It has a very low pressure and winds of at least 75 mi per hour.
IONOSPHERE	the third layer of the atmosphere above the earth, most ionized air
ISOBAR	lines on a map connecting points of equal pressure
ISOTHERM	lines on a map connecting points of equal temperature
JET STREAM	a stream of very high velocity westerly winds - between 20,000 and 40,000 feet altitude
METEOROLOGY	the science of weather and atmosphere
NIMBUS	a dark low rain cloud
PSYCHROMETER	an instrument to measure humidity of the air
RAIN	water drops at least .02 inches in diameter
RELATIVE HUMIDITY	the percent of humidity in the air
SMOG	a combination of fog and industrial smoke
SNOW	water vapor which has been cooled to its freezing point
STRATOSPHERE	the second of four layers of the atmosphere

STRATUS CLOUDS	smooth and shapeless clouds with no vertical movement
TOPOGRAPHY	the physical features, such as shapes, heights and contours of land
TORNADO	very violent storms. A funnel-shaped, rapidly whirling circulation of low air pressure
TRADE WINDS	the tropical belt of easterly wind extending from the equator to the 25th latitudes north and south
TROPOSPHERE	the lowest layer of the earth's atmosphere and where most weather patterns occur
TYPHOON	a hurricane occuring in the Pacific West
WARM FRONT	warm air replacing cold air over a wide boundary
WEATHER	changes that occur in the troposphere due to the interaction of air masses
WESTERLIES	a belt of westerly winds in the temperate zone

APPENDIX 7

HOW TO READ A THERMOMETER

PRINCIPLE: To keep a record of temperature for a four week period

MATERIALS: Thermometer
Graph Paper

PROCEDURE: Make a chart similar to the example below and extend it into a four-week period

Date	Time	Air Temperature	
		°C	°F

Choose an outdoor site where a thermometer can be left permanently. Make sure it is in the shade. Select a specific time each day to record the temperature

EVALUATION: Graph your results.
Answer the following questions:

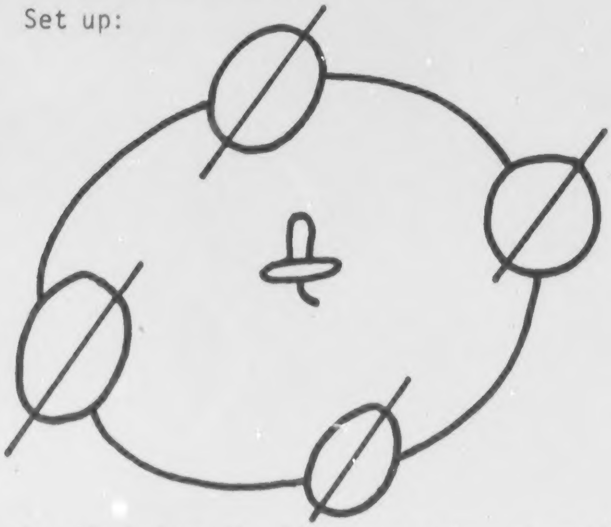
1. Is there any difference in the temperature as the season progresses?
2. Does the temperature get warmer or colder?
3. Were there any cold days?
4. Did this indicate that cold weather was coming?

APPENDIX 8

MATERIALS: Light source
Globe

PROCEDURE: Place light source in center of table. Darken room and observe the amount of light that covers the globe as it is moved in a large elipse around the light.

Set up:



QUESTIONS:

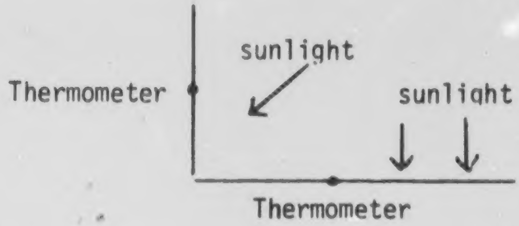
1. What does the light source represent?
2. In which position does the northern hemisphere receive the greatest amount of light?
3. Why is it cooler in our part of the world than at the equator?
4. Explain why clouds would cause less heat to reach the surface of the earth
5. Tell which position produces spring, summer, fall and winter.

APPENDIX 9

PRINCIPLE: The angle of the sun's rays determines the amount of heat a surface receives.

MATERIALS: Two Thermometers
Large Sheets of Dark Paper

PROCEDURE: Have students tape thermometers to back of paper. Place sheets in direct sunlight with one paper flat on a table, the other propped at an angle.


sunlight
Thermometer
sunlight
Thermometer

After several minutes, remove thermometers and read the temperatures.

	Temperature
Vertical	
Slanting	

UNEQUAL HEATING OF LAND AND WATER

MATERIALS: Two pans of 3" - 5" deep

Two Thermometers

150 Watt Light Source

PROCEDURE: Fill one pan with water and the other with soil.

Place a thermometer into the soil and water of each pan

Place the heat source equally over the two pans

Record the temperature of both the soil and water at the beginning of the experiment and at five minutes intervals for twenty minutes on the chart below.

Time	Soil Temperature	Water Temperature
Start		
5 Minutes		
10 Minutes		
15 Minutes		
20 Minutes		

EVALUATION:

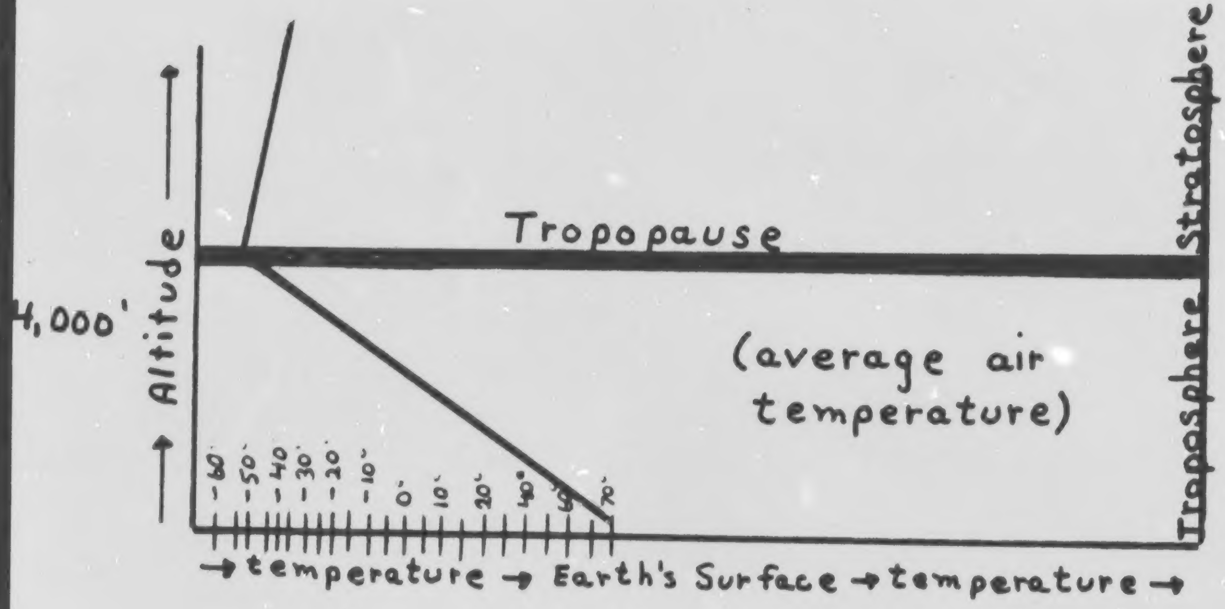
1. What was the total degree change in the water?
2. What was the total degree change in the soil?
3. Would the color of the soil make a difference on the amount of heat it would absorb?
4. Why?

EVALUATION:

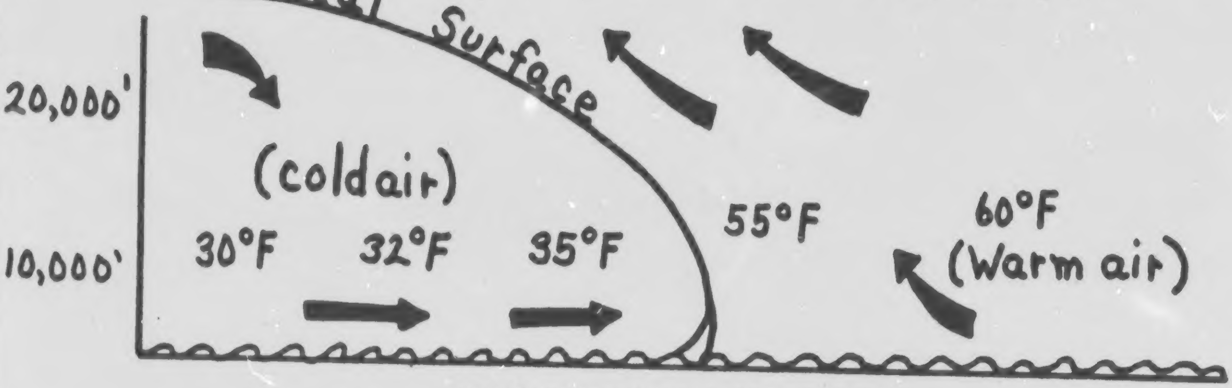
5. What was the total degree change in the Sand?
6. What was the total degree change in the water?
7. What was the average temperature change in the sand?
8. What was the average temperature change in the water?
9. If you were on the beach on a summer day, what changes would you see from morning to noon?
10. What would happen at night?

ADDITIONAL ACTIVITY:

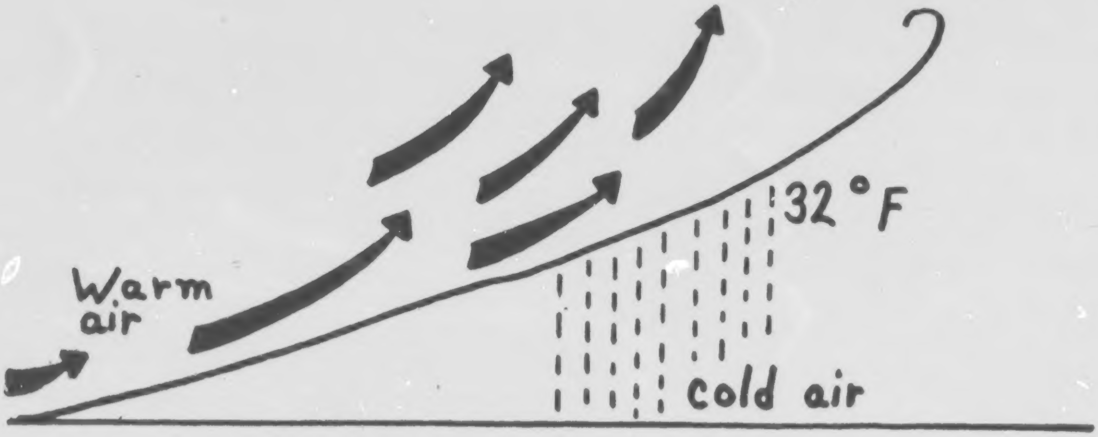
Can you devise an experiment that would show what happens on a summer night at the beach?


Tropopause
Stratosphere
Troposphere
Altitude
4,000'
(average air temperature)
-60°
-50°
-40°
-30°
-20°
-10°
0°
10°
20°
40°
60°
70°
→ temperature → Earth's Surface → temperature →

All weather occurs in troposphere
Average temperature variation with height: 2°C per 1,000 feet.


Frontal Surface
20,000'
(coldair)
10,000'
30°F
32°F
35°F
55°F
60°F
(Warm air)

CROSS SECTION OF A COLD FRONT


Warm air
32 °F
cold air

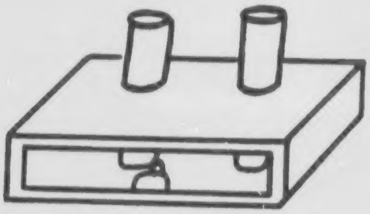
CROSS SECTION OF A WARM FRONT

CONVECTION CURRENTS

PRINCIPLE: Using a convection current box tc illustrate wind currents caused by uneven heating

MATERIALS: Convection current box

Candle



PROCEDURE: Light the heat source (can be a candle), and place under one of the chimneys.

Light a paper towel soaked in water (smoke source) and hold it over the unlighted chimney.

Hold it over the lighted chimney.

EVALUATION:

1. Describe what happened when the smoke source is placed placed on the unlighted chimney
2. What happended when the smoke source is placed on the lighted chimney?
3. Hypothesize why the results are different
4. Make a drawing of what happened in each experiment

APPENDIX 13

EFFECTS OF LOWERED AIR PRESSURE

MATERIALS:

Glass Tubing
Two Hole Stopper
Glass Bottle
Rubber Tubing
Balloon
Modeling Clay
Vacuum Pump

PROCEDURE:

Fasten a small balloon which has been inflated several times to stretch it to the lower end of one of the glass tubing, which has been inserted into a rubber stopper. Attach the length of rubber tubing to the upper end of the other glass tubing and to the vacuum pump. Place the stopper with glass tubing, balloon and rubber tubing in the mouth of a large jar and seal tightly. Partially inflate the balloon by blowing into the glass tube and seal with a lump of clay. Pump the air out of the balloon with the vacuum pump.

EVALUATION:

1. What happened to the balloon?
2. If air is removed from the jar, what happens to the air pressure
3. Explain why the size of the ballon changes

APPENDIX 14

REDUCED AIR PRESSURE

MATERIALS:
Alcohol burner
Large can with lid
Tripod

PROCEDURE: Put a small amount of water into the can and place on the tripod. Heat the can with the alcohol burner until steam begins to come out. Place lid on can and remove heat. Observe the can as it cools.

EVALUATION:
1. Describe what you have observed
2. What caused the can to behave the way it did?

MAKE A CARTESIAN DIVER

PRINCIPLE: To show changes in air pressure

MATERIALS:
Tall glass jar
small vial
Sheet of rubber
Rubber band

PROCEDURE: Fill the large glass jar almost full of water. Partially fill vial and turn it upside down in the water in the jar. If vial sinks, you have too much water, if it floats with the bottom above the water, you have too little. Keep adding/taking away water until the vial floats in the desired position (bottom just about level with the top of the water).

Stretch the sheet of rubber over the mouth of the jar with the rubber band

Press gently on the rubber covering

EVALUATION:
1. What happens when you press down on the sheet of rubber?
2. Why?
3. What happens when you release the pressure of your band?
4. Why?

APPENDIX 16

REDUCED AIR PRESSURE

PRINCIPLE: The pressure of the air varies. With increased altitude air pressure decreases. This is controlled mostly by temperature.

MATERIALS:

Large flask
Cork or rubber stopper
Source of heat
Ice cubes

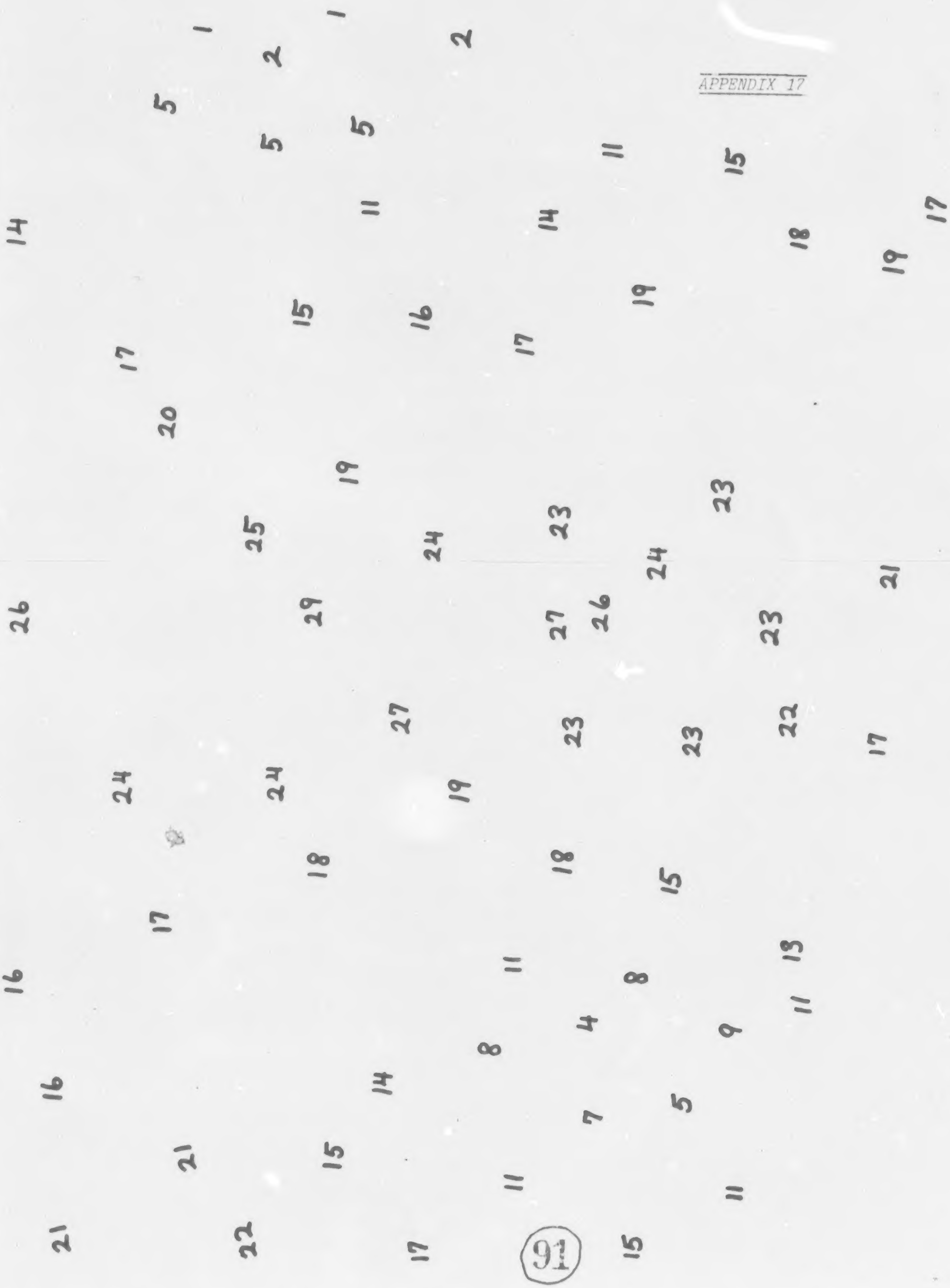
PROCEDURE: Flask should be about 1/2 full of water. Heat until water boils for about a minute. Remove from heat. Place cork in flask (handle with care). After flask has cooled about one minute, carefully invert (caution - be very careful that the cork is securely in place). Now carefully move an ice cube across the bottom (the topside now) of the flask. Water should boil violently as you cool the flask.

EVALUATION:

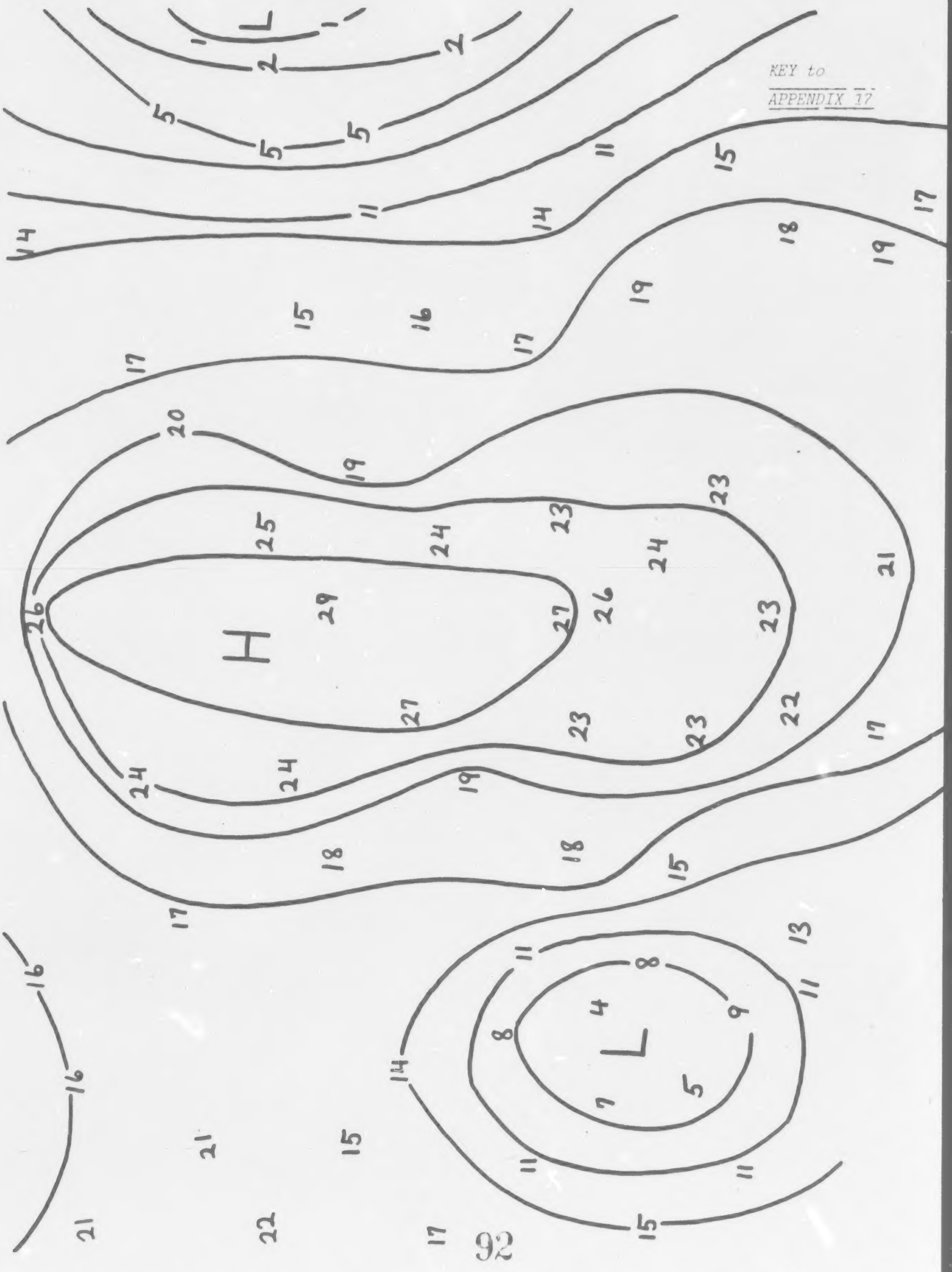
1. Why does the water start boiling again after you have inverted the flask?

2. Can you explain why it takes so long to cook at a high altitude?

APPENDIX 17



KEY to
APPENDIX 17


L
1
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16

APPENDIX 18

ESTABLISHING THE DEW POINT

PRINCIPLE: Water vapor when cooled, changes from a gas into a liquid.

MATERIALS:

Towel
Stirring rod
Ice cubes
Tin can
Water at room temperature
Thermometer

PROCEDURE:

Take lid from the can
Fill can 1/2 full of water
Place thermometer in can
Add ice cubes and stir
Check carefully for water drops on side of can
Record temperature when drops first appear

EVALUATION:

1. If all the air in the classroom was cooled to its dew point, what would happen?

ADDITIONAL ACTIVITY: Repeat this procedure outside the classroom

EVALUATION:

1. Were the results different?
2. What was the effect of adding ice to the water?
3. Where did the moisture that collected on the can come from?
4. What caused the moisture to collect?
5. What two conditions are needed for dew to form?
6. What was the temperature difference between the room temperature and the temperature when the moisture appeared on the can?
7. Why does morning dew or frost disappear?
8. Give three reasons why frost or dew disappear?
9. Why do pipes that carry cold water have moisture on them during the summer?
10. Make a drawing of the experimental set-up.

FACT SHEET

PRECIPITATION:

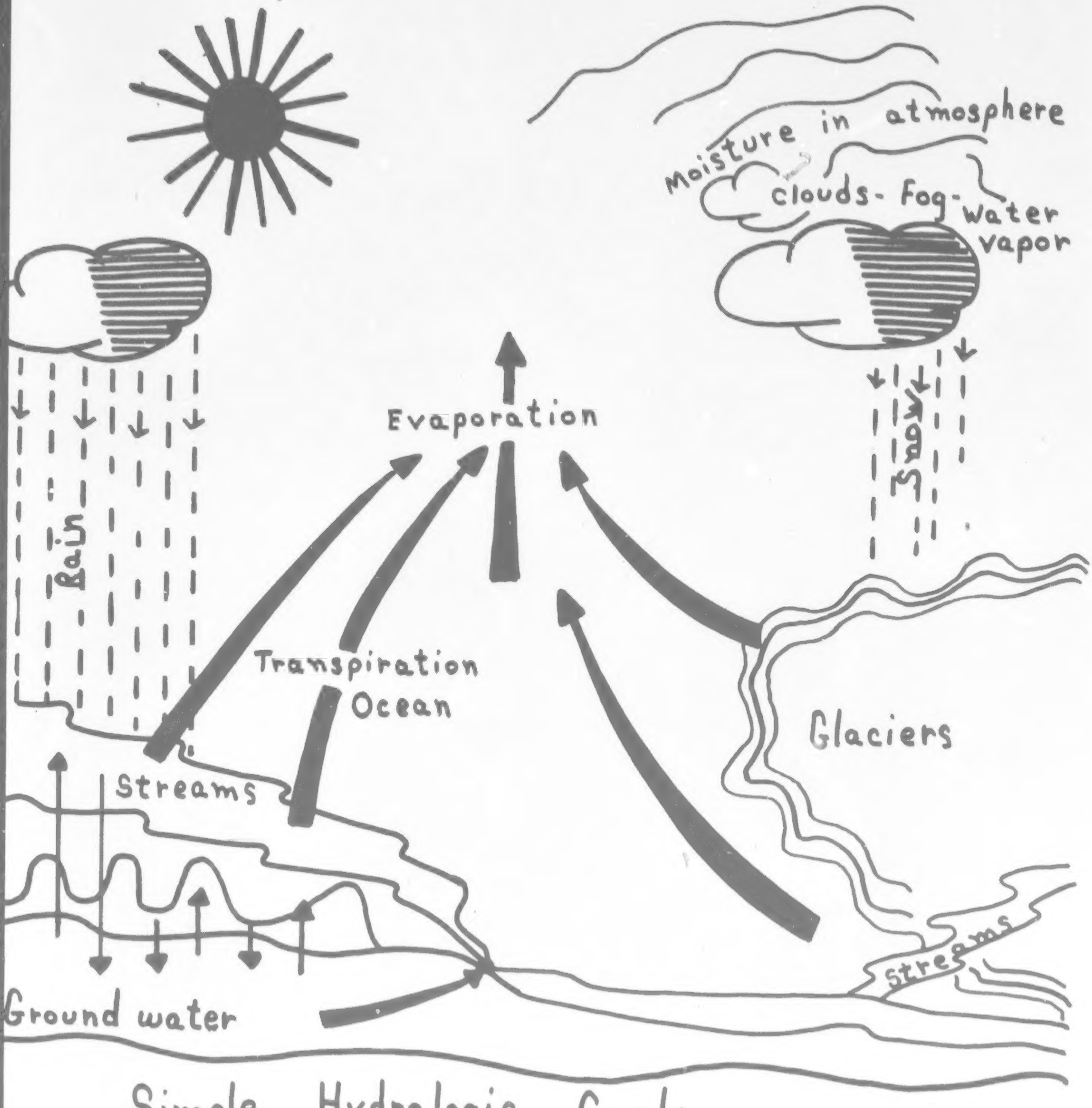
1. Rain is the result of the rising and cooling of moist air. Moisture in the air condenses into droplets which get larger as they collide with each other. They fall to earth when they are sufficiently heavy. In the Bay area the amount of rainfall varies tremendously.

2. Snow is formed when the water vapor in the upper levels of clouds freezes. They may then pass through the lower levels of the clouds and more cloud droplets will freeze on the original droplets making snow flakes like feathery fronds.

3. Sleet is formed when rain freezes as it falls. Sometimes drops of rain start to fall and are carried up to where the temperature is below freezing. They freeze and start to fall again. In passing through warmer air, they may pick up more water vapor. If the air is turbulent, they may make this trip many times before they become too heavy for the air currents to carry and fall to earth as hail.

4. Fog is a cloud that forms just above the ground. Warm moist air passes over a cold surface and the moisture in the air is cooled below the dew point of water. Millions of tiny water droplets are seen as fog.

5. Frost is usually formed on still, clear nights when the temperature of the air is at or below 0° Celsius. It is frozen moisture on solid objects.


Moisture in atmosphere
Clouds - Fog - water vapor
Evaporation
Rain
Snow
Transpiration
Ocean
Streams
Glaciers
Streams
Ground water

Simple Hydrologic Cycle

WINDS

1. Warm air expands and rises
2. Earth rotates from west to east
3. Air tends to equalize its pressure
4. Air moving across the surface of the earth tends to curve to the right in the northern hemisphere
    - a) this is also true of the currents in the ocean, rockets and projectiles. Those who fire a rifle know how they must compensate for the drift of the bullet.
5. Wind speeds are usually higher over water than over land
6. Winds are named for the direction in which they blow
7. Certain winds blow with predictable regularity
    a) Trade Winds b) Westerlies
8. Hurricanes - the most destructive of the storms. They form mostly within 20° from the equator, and may be 30 miles wide. The eye of the hurricane is the center of low pressure around which winds spiral inward at speeds of 75 to 200 miles per hour. Hurricanes sometimes travel at speeds of 50 miles per hour.
9. Tornados - winds travel at speeds up to 500 miles per hour. Usually no more than 200 yards across with very strong upward currents.

FACTS ABOUT THE WORLDWIDE SYSTEMS OF WINDS

Horse Latitudes - are in a region known for its calms or lack of winds. It lies across the Atlantic Ocean near the Tropic of Cancer. Sailors in colonial days named these areas the horse latitudes because their ships were becalmed (unable to move) and several animals such as horses died because of no water. In one report, it was said that one particular ship lost so many horses that the waters around the ship were full of floating dead horses.

Doldrums - a belt of calms and light or sudden breezes near the equator mainly over the ocean. The name doldrums means listlessness. Seamen were first to use this name because their sailing ships were often becalmed. In the doldrums, the air moves upward and causes sudden thunderstorms and gusting winds that make this area the rainiest region in the world. It is also very dangerous to airplanes because the turbulent clouds are several miles higher than any airplanes can fly.

Prevailing Westerlies - a wind that blows over the north and south middle latitudes in an easterly direction. The prevailing westerlies over the Pacific Ocean blow with such a force that seamen sometimes called these winds the prevailing forties. Over the great land masses of the northern hemisphere, the westerlies are often turned from their course by mountain ranges. They are also interrupted by great cyclonic storms common over lands flying from east to west.
The United States and the southern half of Canada lie within the path of the westerlies. The direction of these winds may change near the surface but it is usually steady in the upper air. The prevailing westerlies make flying from west to east faster than from east to west.

Trade Winds - are strong winds that blow toward the equator from the northeast in the northern hemisphere and southeast in the southern hemisphere. In the days of the sailing ships, sailors depended greatly on the trade winds. The paths of the winds were so regular, especially over the oceans, that early navigators named them the trade winds which in the language of the day meant course or trade winds. The trade winds are a part of the great system of winds that blow over the north and south latitudes. The difference between the temperature in the low latitudes and the temperatures in the polar regions cause the trade winds. The heating of the air on the low latitudes makes the air expand and become light. This creates an area of low pressure near the surface, and the cooler and heavier air from the polar regions then tends to flow in to fill the area of low pressure.

These polar winds do not blow due north or due south because of the eastward whirling of the earth. Instead these winds blow from the northeast and from the southeast.
Trade winds have a great deal to do with the rainfall on land. When trade winds blow against mountain ranges, they are forced upward. As the warm air rises it cools and its moisture falls as rain on the mountain slopes.

Regions of Calms - are places in the atmosphere which usually have little or no winds. Several areas of the earth's surface are known regions of frequent calms. These regions of calms include the northern and southern horse latitudes, the northern and southern sub-polar regions, and the equatorial doldrums. All of these calms may be disrupted by sudden storms.

Subpolar Lows - The general circulation of air causes the cold air over the North and South Pole to sink. This sinking of cold air forms the polar anticyclones. Since the cold air hugs the earth's surface, periods of calms are not so persistent as in the warmer regions that have calms.

Jet Streams - are found from six to nine miles high in the atmosphere. They were first discovered by the Japanese during World War II. The wind speed of the jet stream can reach a speed of 400 miles per hour and blows from west to east. Pilots often take advantage of the jet stream to make better time between California and New York.

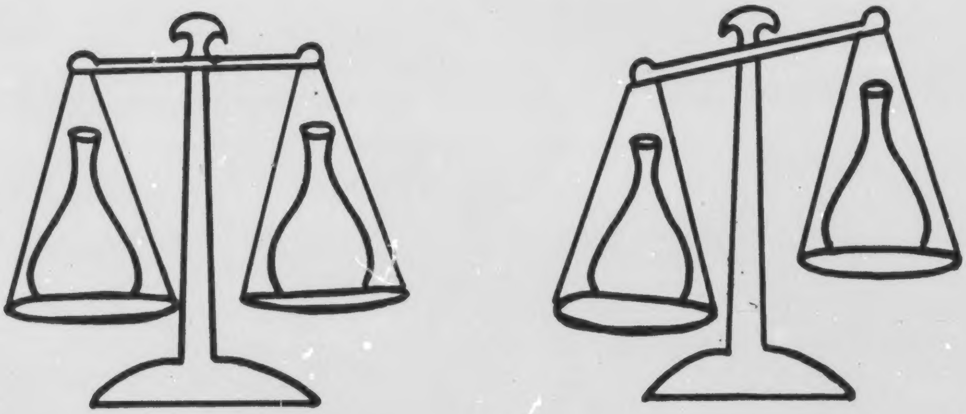
APPENDIX 21c

WHAT CAUSES WINDS

MATERIALS:

- Two flasks
- Two balances
- Heat source

PROCEDURES: Place two flasks on a balance and balance them by using additional weights. Carefully heat one of the flasks and observe what happens.

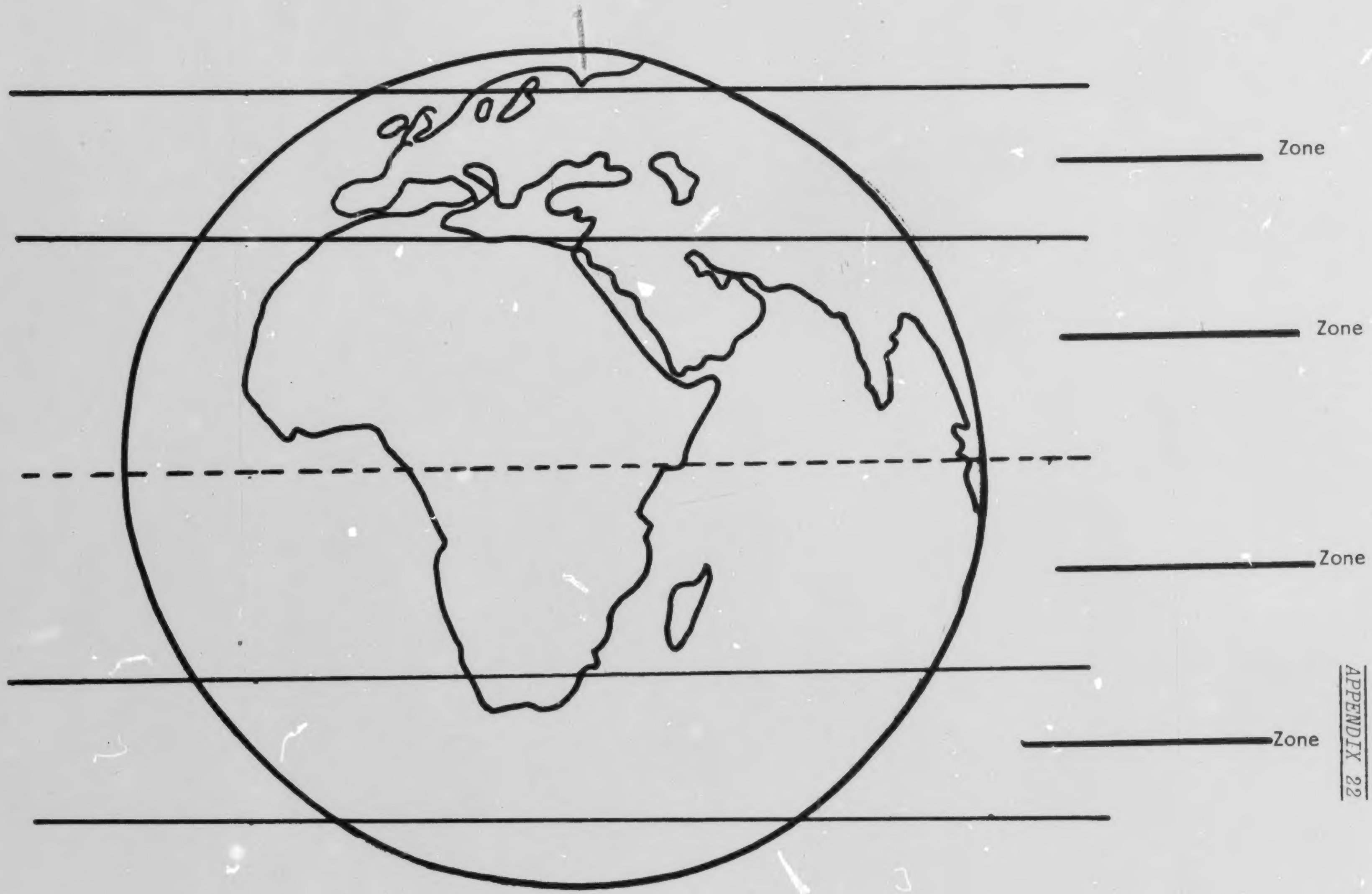


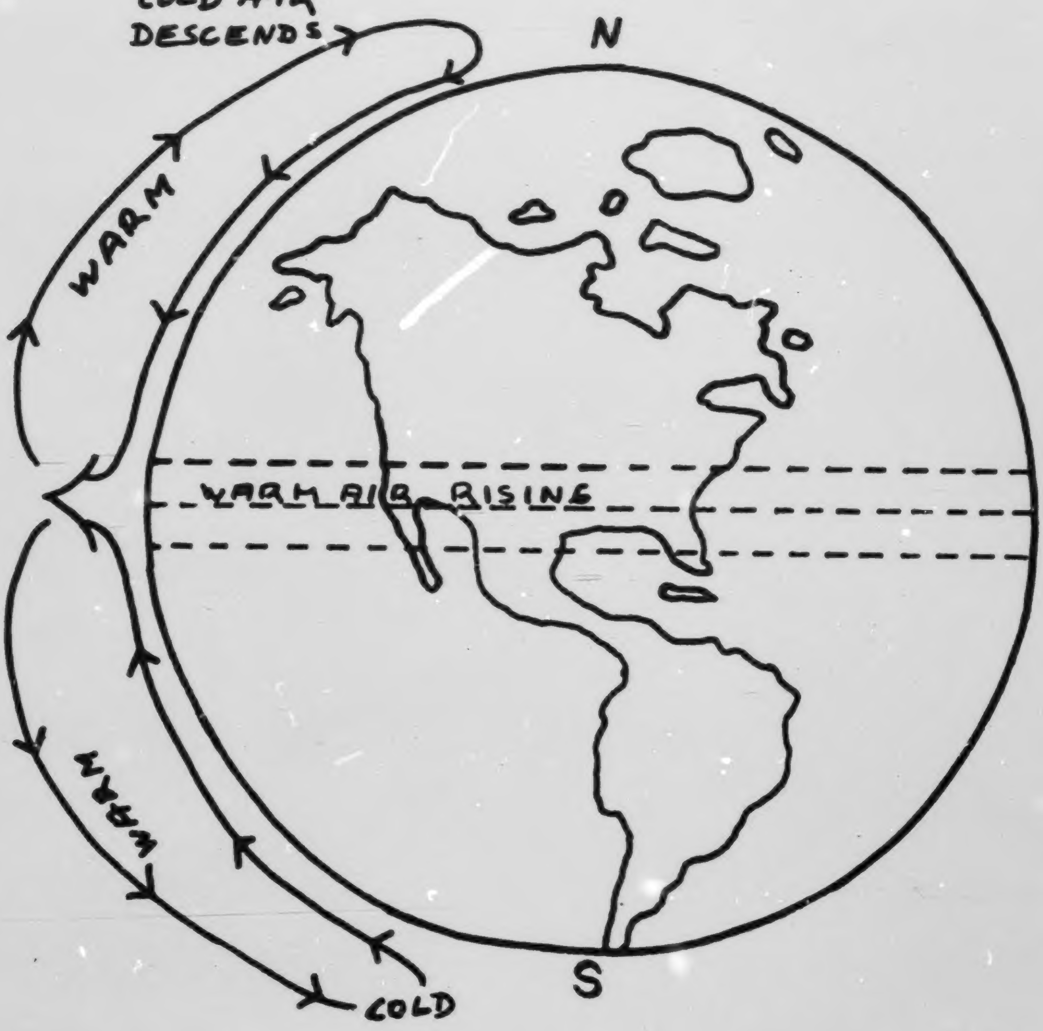
EVALUATION:

1. In the diagram above label the flask which has been heated
   a) Explain the difference
2. Explain why the unequal heating of the earth's surface produces wind
3. Why do you think a sea breeze is produced during the day?
4. Why is the land breeze usually produced at night?
5. How do high mountains of the Bay affect wind speed?
6. What happens to the surrounding cooler air when heated air rises over a part of the earth?

APPENDIX 22

CLIMATE ZONE MAP


Zone
Zone
Zone
Zone


COLD AIR DESCENDS
N
WARM
WARM AIR RISING
WARM
COLD
S

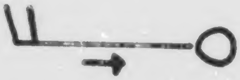
SIMPLIFIED BEAUFORT SCALE

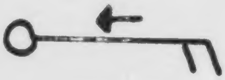
Beaufort #	Explanatory Titles	Effect of Wind		Miles per hour	Weather Bureau Forecast Terms
		On land	On sea		
0	calm	smoke rises vertically	sea completely smooth	less than 1	light
1	light air	smoke drifts	small ripples	1 - 3	
2	light breeze	leaves rustle	short, pronounced waves	4 - 7	
3	gentle breeze	leaves and twigs in constant motion	crests begin to break	8 - 12	gentle
4	moderate breeze	raises dust, loose paper, small branches removed	long waves, many white caps	13 - 18	moderate
5	fresh breeze	small trees begin to sway	white foaming crests everywhere	19 - 24	fresh
6	strong breeze	large branches in motion, overhead lines begin to whistle. Umbrellas used with difficulty	large wave crests more extensive	25 - 31	strong
7	moderate gale	whole trees in motion difficult to walk	foam blows in streaks	32 - 38	strong
8	fresh gale	twigs break off trees	foam blows in streaks	39 - 46	gale
9	strong gale	light damage to roof and houses	foam blows in streaks	47 - 54	gale
10	whole gale	trees uprooted	high waves, great foam patches	55 - 63	whole gale
11	storm	widespread damage	ships hidden in troughs of waves	64 - 75	whole gale
12	hurricane	devastation	ships hidden in troughs of waves	above 75	hurricane

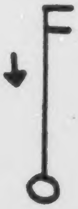
APPENDIX 24

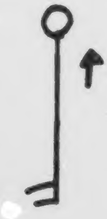
WEATHER MAP SYMBOLS FOR WIND

Direction of Wind:

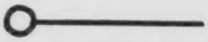

West Wind

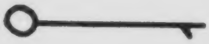

East Wind

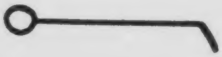

North Wind

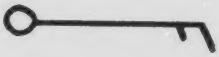

South Wind

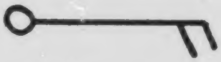
Number of tails indicate speed of wind:

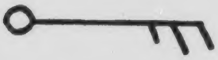

calm - 1-4 mph

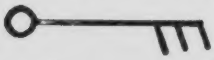

5 - 8 mph

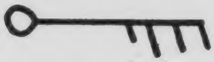

9 - 14 mph

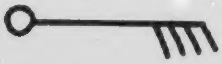

15 - 20 mph

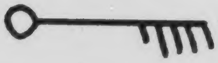

21 - 25 mph

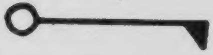

26 - 31 mph

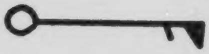

32 - 37 mph

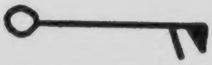

38 - 43 mph

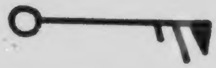

44 - 49 mph

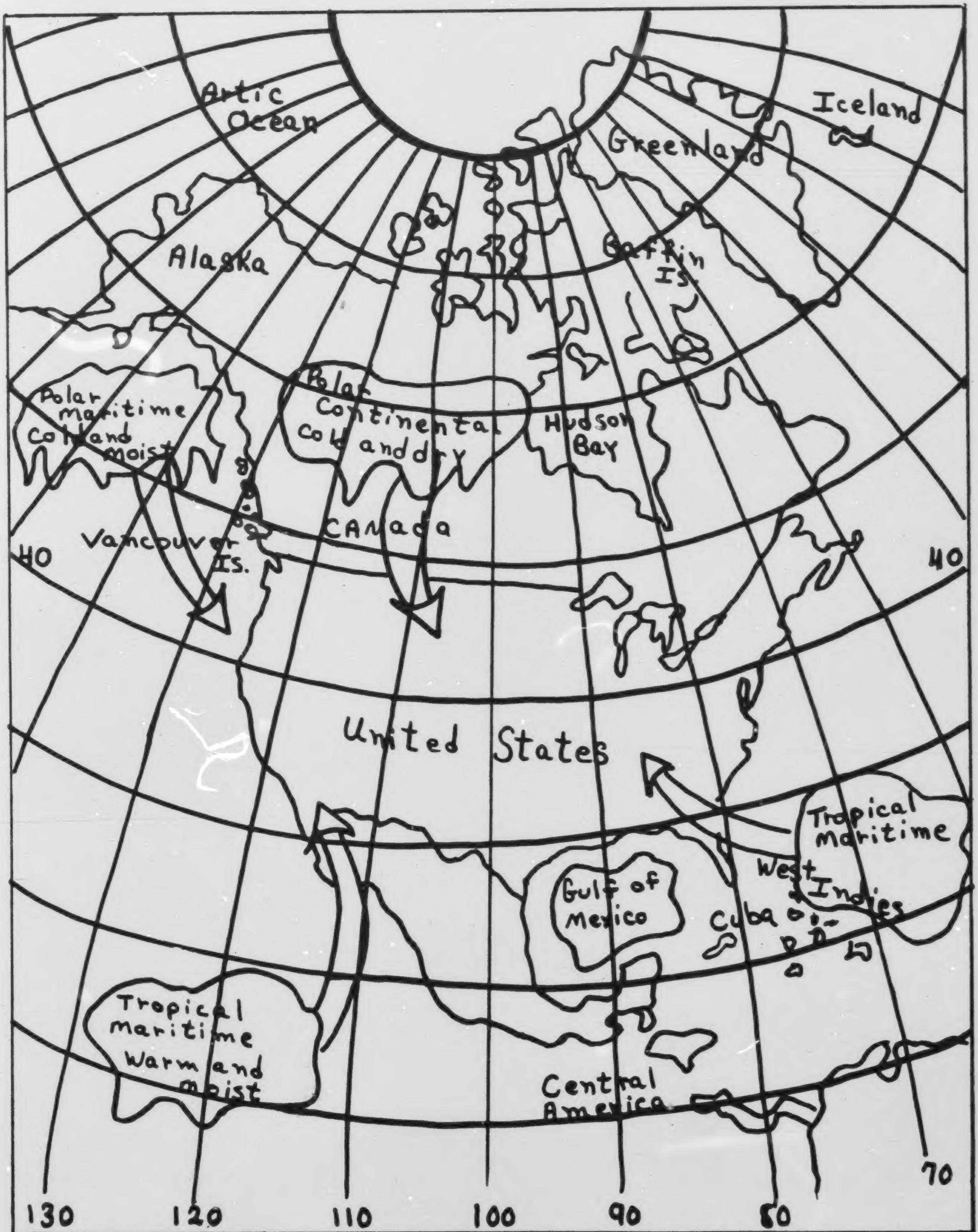

50 - 54 mph


55 - 60 mph


61 - 66 mph


67 - 71 mph


72 - 77 mph


Artic Ocean
Iceland
Greenland
Alaska
Baffin Is.
Polar maritime Cold and moist
Polar Continental cold and dry
Hudson Bay
CANAda
Vancouver Is.
40
40
United States
Tropical maritime
West Indies
Gulf of Mexico
Cuba
Tropical maritime Warm and moist
Central America
70
130
120
110
100
90
80

Air Masses of North America

APPENDIX 26a

FORMING CLOUDS

PRINCIPLE: Clouds are tiny drops of water. When the temperature gets cold, the drops get together and form clouds

MATERIAL:
Quart or larger jars
Matches

PROCEDURE:
1. Wash mouth of jar only (do not get inside of jar wet)
Place lips on mouth of jar and force air into jar
Remove the jar quickly from mouth

EVALUATION:
1) Did you form a cloud?

PROCEDURE:
2. Put about a tablespoon of water into the jar
Turn the jar to get the sides wet
Place lips on mouth of jar and force air into it
Remove quickly from mouth

EVALUATION:
1) Was there fog?
2) Was there more or less fog than in Procedure 1 ?

PROCEDURE:
3. Hold the mouth of the jar upside down
Light a match and wait until it begins to burn steadily
Blow the match out and let the smoke enter the jar
Repeat Procedure 1

EVALUATION:
1) Was fog observed?
2) How does this fog compare to the fog in Procedure 1 & 2 ?

PROCEDURE:
1. Rinse out the jar let drain and dry
Put some smoke inside the jar as explained in Procedure 3
Repeat Procedure 1

EVALUATION:
1) Did a cloud form?
2) What three conditions are needed to form a cloud?

APPENDIX 26b

HOW CLOUDS FORM

PRINCIPLE: There are two forms of water that come from a boiling tea kettle

MATERIAL: Any steam generating device such as a tea kettle

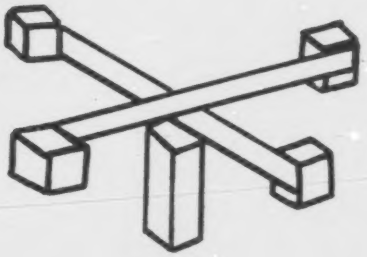
PROCEDURE: Observe and draw what you see happening

EVALUATION: The cloud near the spout is made up of water droplets

1. Where did the water come from?
2. What evidence from the boiling tea kettle do you have that shows water in an invisible form?

APPENDIX 27

MAKING AN ANENOMETER



MATERIALS:

Five half gallon milk cartons
Two 24 inch sticks
Short length of wood
Washers
Waterproof glue
Finishing nail

PROCEDURE:

Leave about four inches to the bottom of the milk cartons when you remove the tops

Mount the milk carton bottoms with some thumbtacks to the pair of sticks

Cross the sticks in the middle and fasten with glue and some electrical tape

Drive the nail into the crossed sticks and move back and forth until the sticks rotate freely

Mount the apparatus on the piece of wood making sure the washers are between the crossed piece and the piece of wood

Calibrate the anenometer by having someone drive at different speeds while you count the number of revolutions the appartus makes.

EVALUATION:

1. Why was waterproof glue used?
2. When you callibrated the instrument, was it hard to count the number of turns?
3. What would you suggest in order to improve the design?
4. At what speed did you find it impossible to count the number of turns?

APPENDIX 28

MAKING A WIND VANE

MATERIALS:
Any material that can be cut or sawed into an arrow such as milk cartons
Flat stick 12 inches long
Nail
Short piece of wood

PROCEDURE:
For best results, cut the tail part of the arrow at least twice as big at the point
Staple or thumbtack the pointer and tail of the arrow to the stick
Drive the nail through the center of the stick and make sure the wind vane is able to turn freely
Using a washer between the wind vane and the short piece of wood, drive the nail into the wood

EVALUATION:
1. How are the winds named?
2. Why is it necessary to locate the wind vane as high as possible from the ground?
3. What else interferes with a correct indication of where the wind is blowing where you have your wind vane?

APPENDIX 29

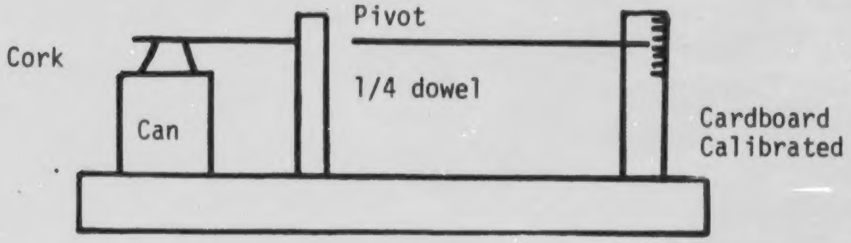
MAKING A BAROMETER

MATERIALS:

Small can (similar to an evaporated milk can)
Wood base 4" x 12" (any available thickness)
Balsa strip 12" x 1/8" x 1/8"
Sealing wax (if available, some means of soldering)
Dowel stick 1/4"
Cork
Cardboard to make a scale
Barometer - commercial to use for calibration

PROCEDURE:

Seal the small can's topholes with sealing wax or if available a soldering gun
Cement the cork to the top of the can on its center point
Place the can on the wood base
Drill a 1/4" hole in the base next to the can for the dowel and glue the dowel in its place
Fasten the balsa strip onto the dowel by means of a straight pin and make sure the balsa strip can move freely
One end of the strip rests on the cork while the other is near the cardboard scale
Calibrate the barometer by using a store-bought barometer or by using the daily weather forecasts on TV or radio



EVALUATION:

1. As the pressure increases the pointer moves __________
2. If the pointer moves down that means there is __________ air pressure.

APPENDIX 30

MAKING A HYGROMETER

MATERIALS:

Two thermometers
Shoestring
Mounting board (pegboard)
Small jar (baby food jars)

PROCEDURE:

Mount the two thermometers on the pegboard
Attach a shoelace to one of the thermometer bulbs
Fill the jar with water and insert shoelace in jar

When shoelace is wet, fan both thermometers and record the temperatures

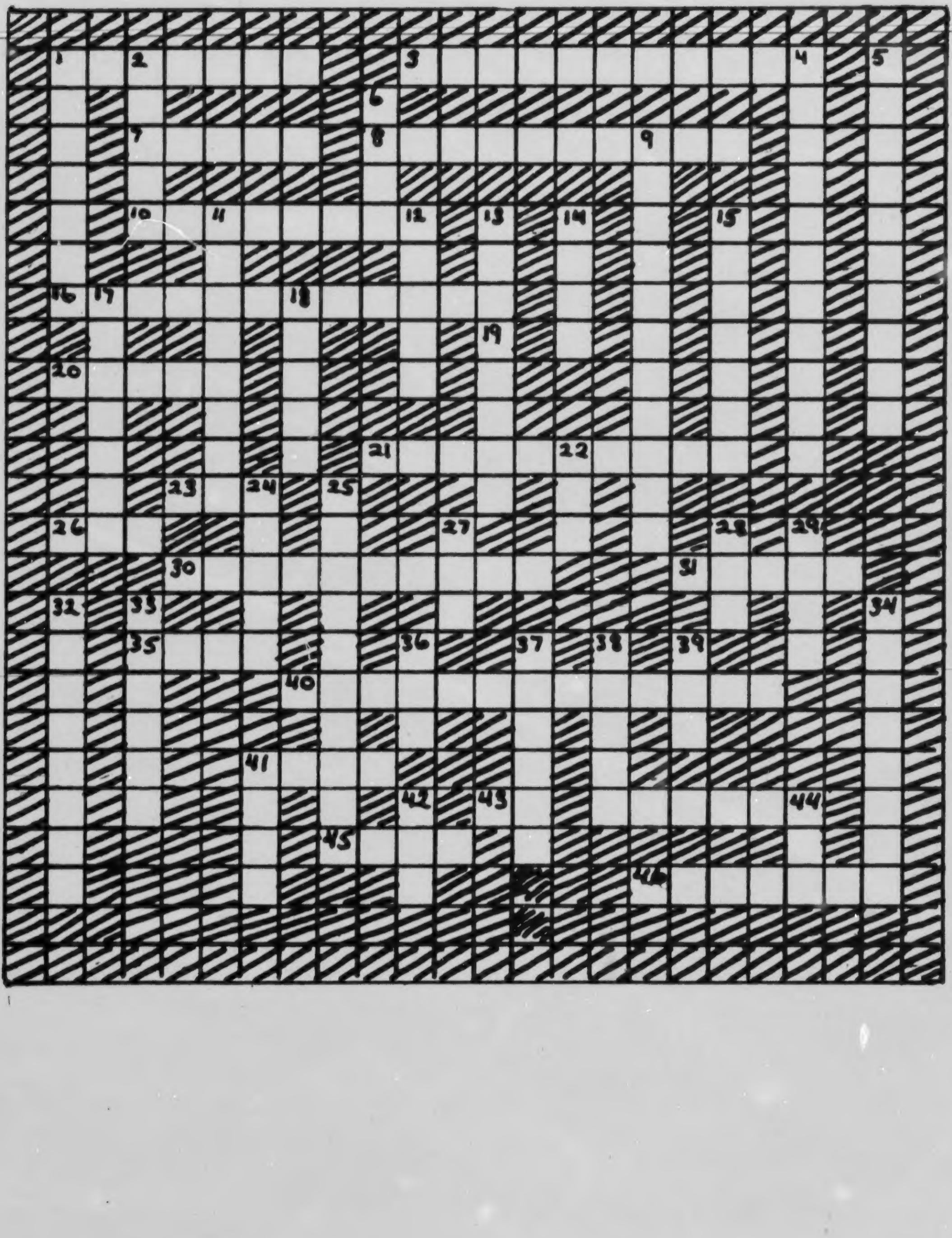
EVALUATION:

1. Was there a difference between the two thermometers?
2. Can you explain what caused this difference

KEEPING A WEATHER RECORD - FINAL EVALUATION

Date & Day	Hour of Day	Amount of Rainfall	Barometric Pressure	Temperature	Relative Humidity	Wind Direction	Wind Speed	Type of Clouds	Probable Weather Conditions
Mon									
Tues									
Wed									
Thur									
Fri									
Sat									
Sun									
Mon									
Tues									
Wed									
Thur									
Fri									
Sat									

CROSS WORD PUZZLE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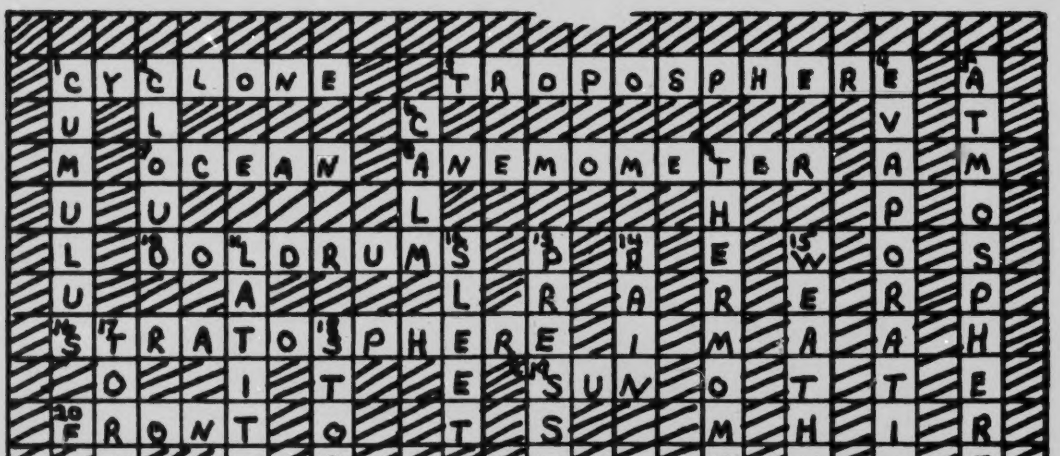
ACROSS

1. A large whirlpool sometimes called a low
3. Layer of air in which all weather occurs
7. Contains most of the earth's waters
8. Instrument to measure wind speed
10. Tropical belts of light winds and calms near the equator
16. Second layer of earth's atmosphere
19. The center of the solar system
20. Weather band in the separation and between the air masses
21. Instrument used to measure humidity
23. Condensed water vapor deposited on cooled surfaces
26. Warm moist air moving in
30. The third layer of the atmosphere
31. Makes up 3/4 of the earth
35. A particle with an electric charge
40. When water vapor in the air condenses and falls to earth
41. Produced when rain is carried aloft and frozen before it falls to earth
43. A violent tropical storm with winds above 75 miles per hour
45. Water vapor that freezes in the form of crystals or flakes
46. A phenomena that recurs in a regular fashion and in the same sequence

DOWN

1. Thick cauliflower-like clouds
2. A visible mass suspended in the air
4. To pass off into vapor
5. The envelope of air just above the earth
6. Air that is free of motion
9. Measures temperature
11. Distance in degrees north and south of the equator
12. Rain that freezes as it falls to earth
13. Force due to weight of air
14. Precipitation in form of drops
15. Day to day changes in the troposphere
17. Low pressure, funnel shaped storm
18. Violent disturbance of air
22. A representation of the weather for an area
24. Movement of air over earth's surface
25. Winds blowing from the east
27. A stream of high velocity westerly winds between 20,000 and 40,000 altitude
28. Not a solid or a liquid but has weight
29. An area especially characterized by a type of wind
32. To change water vapor to water droplets
33. Highest level clouds made up of ice crystals
34. The water vapor content in the air
36. Frozen water
37. A rain cloud, low and dark
38. Visible condensation of moisture
39. The invisible mixture of gases that surround the earth
41. A region where a great mass of air collects, usually means fair weather
42. Tiny particles of water vapor
44. The center of a hurricane

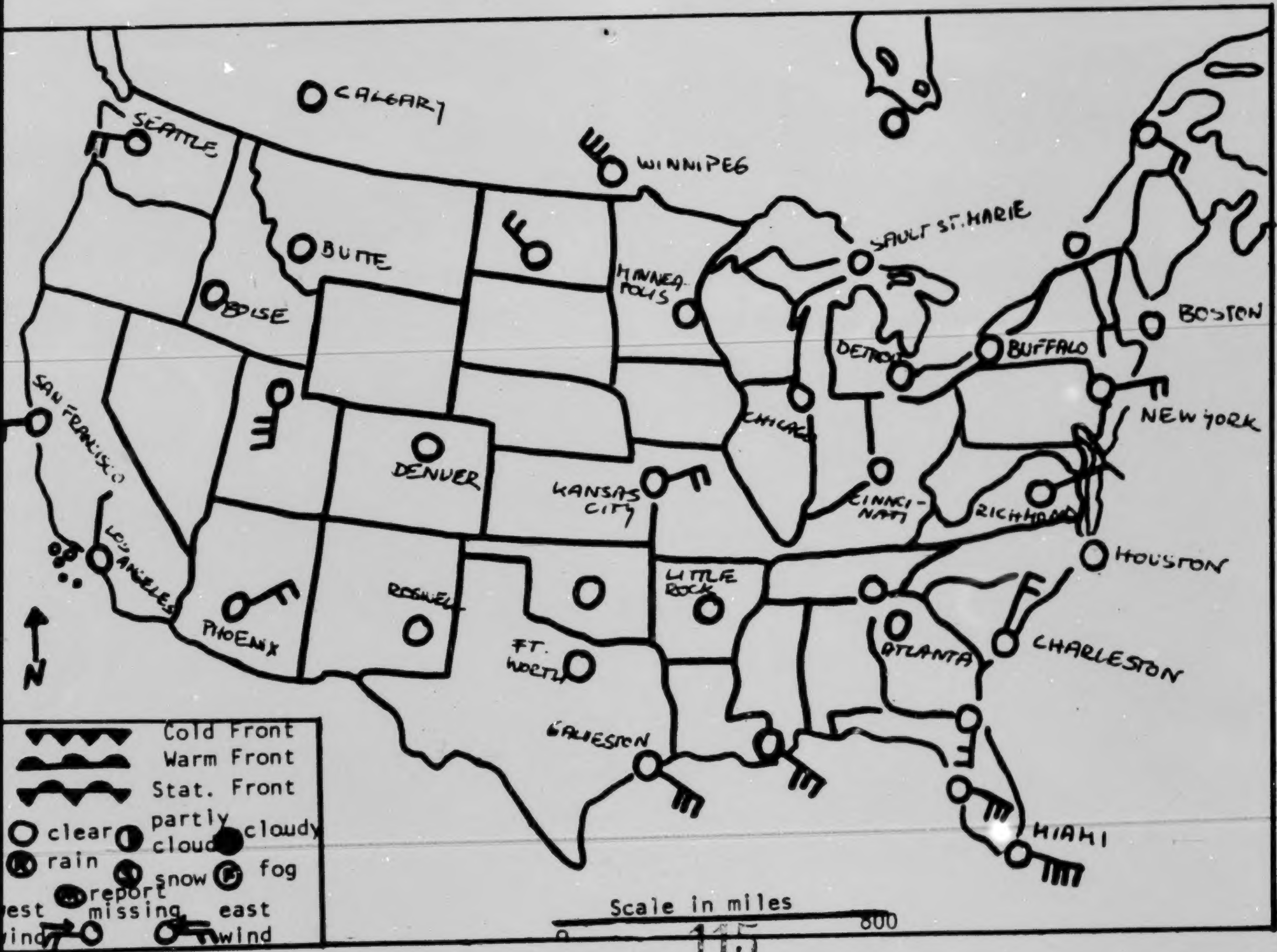
KEY TO CROSSWORD PUZZLE


CYCLONE
TROPOSPHERE
OCEAN
ANEMOMETER
DOLDRUMS
STRATOSPHERE
SUN
FRONT
HYGROMETER
DEW
LOW
IONOSPHERE
WATER
IONS
PRECIPITATION
HAIL
HURRICANE
SNOW
CYCLE
CUMULUS
EVAPORATION
ATMOSPHERE
THERMOMETER
TORNADO
CONDENSE
CIRRUS
HUMIDITY

READING A WEATHER MAP

From the map below read the indicated air speed and the direction from which it is blowing and write it in the appropriate blank.

City	Windspeed	Direction
San Francisco	____________	____________
Los Angeles	____________	____________
Phoenix	____________	____________
Miami	____________	____________
New York	____________	____________
Galveston	____________	____________


CALGARY
SEATTLE
WINNIPEG
SAULT ST. MARIE
BUTTE
BOISE
MINNEAPOLIS
BOSTON
SAN FRANCISCO
DETROIT
BUFFALO
NEW YORK
CHICAGO
DENVER
KANSAS CITY
CINCINNATI
RICHMOND
HOUSTON
LITTLE ROCK
ROSWELL
LOS ANGELES
PHOENIX
FT. WORTH
ATLANTA
CHARLESTON
N
GALVESTON
MIAMI
Cold Front
Warm Front
Stat. Front
clear
partly cloudy
cloudy
rain
snow
fog
report missing
est
ind
east wind
Scale in miles
0
800

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currents-tides-waves

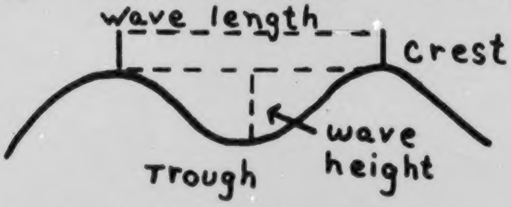
WAVES

I. WHAT IS A WAVE?

A. Wave structure

Upon completion of this unit, the student should be able to state that:

1. waves are really series of forms that are pushed along by winds
2. water molecules move in circular motion
3. as these particles are moving in a circular pattern, and the waves approach the beach the circles hit the bottom which causes the tops to break off causing breakers
4. the parts of a wave are:
   a) the crest - the highest part of the wave
   b) the trough - the lowest part of the wave
5. the wave height (H) is the vertical distance from crest to trough
6. the wave length (L) is the horizontal distance from crest to crest



7. the wave period (T) is the time in seconds for a wave crest to travel the distance equal to one wave length
8. the wave frequency is the number of T per second
9. there are three types of waves:
   a) Progressive waves - simply a series of waves moving forward over the water surface
   b) Summer waves - moved by a gentle wind toward the shore
   c) Winter waves - stirred by a strong, gusty wind blowing for a long time over a long distance
10. the size of waves is influenced by the velocity of the wind, angle of the wind and distance the wind has blown, length of time.

Reference 10 *Appendix 1, 2 & 3*

B. Wave movement

Reference 10 *Appendix 4 & 5*

II. THE EFFECTS OF WAVES ON ABIOTIC COMPONENTS

Upon completion of this unit, the student should be able to state:

A. by experimenting and discussing about waves, the effects of waves on different types of beaches (rocky and sandy), harbours and conformations

Appendix 6

B. the effects of waves on the ocean floor

Appendix 7

C. whether waves are important in mixing up nutriments in the ecosystem

Appendix 8

D. whether waves have any effect on amount of dissolved oxygen in the water

Appendix 9

III. THE EFFECT OF WAVES ON BIOTIC COMPONENTS

Upon completion of this unit, the student should be able to:

A. list at least four adaptations that organisms have to withstand waves

Reference 8 *Appendix 10*

B. what effect waves have on the spray zone

Reference 15 *Appendix 11*

IV. MAN AND WAVES

Upon completion of this unit, the student should be able to state:

A. man's effects on the sea and the sea's effects on man

Appendix 12

B. that "killer" waves - tsunamis, are giant waves caused by earthquakes or volcanic eruptions. They are not due to tidal forces

Appendix 13

See Appendix 14 for Field Trip

WHAT MAKES WAVES?

EQUIPMENT: Shallow pan of water (wall paper tray works nicely)
Electric fan

PROCEDURE: Fill the pan with approximately 2 inches of water
Place rocks on sand at one end of the pan
Turn the fan toward the water and note how the surface is set in motion
Increase the speed of the fan

QUESTION: What happens to the little waves?

PROCEDURE: Now place a rock in the water and repeat the activity

QUESTION: How does the obstruction change the waves?

DISCUSSION:
1. What makes waves?
2. What makes wind?
3. What makes earthquakes?
4. What makes landslides?
5. What makes volcanic eruptions?

PARTS AND SIZES OF WAVES

EQUIPMENT: Shallow pan of water
Electric fan
Spatula
Piece of glass

PROCEDURE: Using the equipment at your station, make waves and observe them carefully.

Draw a wave, label its parts:

a) crest
b) trough
c) length
d) height

Continue to make waves using the equipment available

By observing the wave-tank, list the four wind factors that influence wave size

a) Velocity of wind - vary fan speed
b) Angle of wind - change angle of fan
c) Distance of wind blown - shorten length of tank
d) Length of time

NOTE: Have glossary available

APPENDIX 3

TYPES OF WAVES

EQUIPMENT: Wave tank (see appendix 1)

PROCEDURE: Waves can be classified into two types: summer- and winter waves
Use the glossary to find out what the term means
Experiment to make these types of waves
Make a drawing of each type of wave and label it

HOW DOES A MOLECULE OF WATER MOVE IN A WAVE?

EQUIPMENT: 10 gal. aquarium (thin and tall better than wide and short) filled with 1/4 to 1/3 tapwater
Sheet of plastic cut to the exact size of front side of aquarium
Felt pen or black crayon for marking one inch squares on plastic sheet - tape to the aquarium
3/4 inch wooden block cut the exact width plus one third of the inside of the tank bottom
Long metal or wooden bar attached to the block
Lamp placed behind tank, so it will stand out
Cork

PROCEDURE: Place the cork on top of the water and gently move block of wood up and down

QUESTIONS:

QUESTIONS:
1. How does the cork move? Forward ____ Backward___
2. How long does the water move back and forth in the tank after you start the wave motion (oscillation)?

See Reference 2 & 10

HOW DO WAVES MOVE?

EQUIPMENT: Rope, eight feet long

PROCEDURE:
Take piece of rope and give one end to another student
Stand apart from each other in a straight line
Hold rope loosely so that it almost touches the ground
Now give your end of the rope a quick up and down movement
Watch how this single wave motion travels from one end to the other

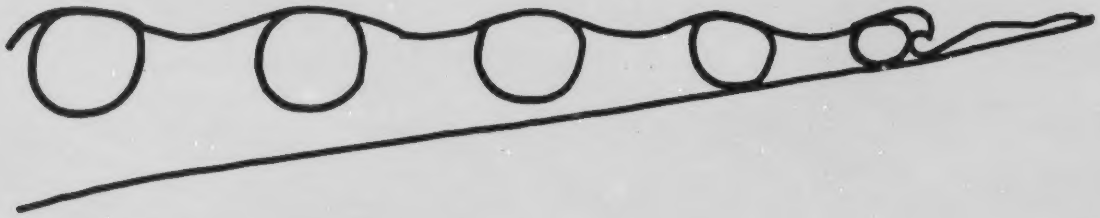
QUESTION: Did the rope itself move forward? *

PROCEDURE: Repeat the experiment to see how waves move.

** If you observed carefully, you discover it did not*

WHAT IS A BREAKER?

As the circle of the wave approaches the beach, the bottom of the ocean floor pulls back on the circle (or orbit) of the wave, causing the top to break off, forming a breaker.



PROCEDURE: See if you can make breakers in your tank

EVALUATION: Describe the breaker principle.
(The particles of water are traveling in circles)

APPENDIX 6

HOW DO WAVES EFFECT SHORELINES?

EQUIPMENT: Wave tank or stream table
Sand
Rocks
Fan
Spatula

PROCEDURE: Build a rocky beach in the following formations

Using summer and then winter waves test each of the above conformations
Describe your results after five waves, then 10, 20 and 50.
Do the above conformation using a sandy beach, using summer and then winter waves
Test each of the above conformations
Describe your results

QUESTIONS:

1. The force of a wave can be as high as 1 ton/sq/ft
   What does this tell you about wave action on the shoreline?
2. Levees are devices which hold back water from the land when the land is lower than the water level. Levees in the delta region are made of mud and rock. In the Sacramento Delta area there are waves creates by wind and boats.
   What effect would you think wave action has on the levees?

See Reference 13

WHAT ARE THE EFFECTS OF WAVES ON THE OCEAN FLOOR?

EQUIPMENT:

- Wave tank or stream table
- Sand (regular and colored)
- Fan
- Spatula

PROCEDURE:

Place a layer of colored sand (making a top layer) on the bottom sands in your tank.

Let it stand for a few minutes

Make each of the following waves and record your findings

Type of Waves	(Drawing or sentence) What happened to the bottom sediment?
Summer Waves	
Winter Waves	

APPENDIX 9

DO WAVES EFFECT MIXING OF NUTRIENTS?

EQUIPMENT:
Wave tank
Food coloring
Fan

PROCEDURE:
Take the tank and build a straight sand or rocky shore at one end
Drop five drops of food coloring on a dry area of the beach
Make summer waves
Measure the length of time it takes for the color to completely diffuse (mix uniformly)
Set it up again, use winter waves
Set ip up again, use no waves

Fill in chart:

Type of wave	Time to diffuse
Summer	
Winter	
None	

PROCEDURE:
Mix several different size particles together*
Make a beach (using the mixture) at right angles to the wave action
Let the waves continue for a few minutes

EVALUATION: Describe what happens?

PROCEDURE: Continue the waves for another several minutes

EVALUATION:
Describe the results
Make a drawing and list your conclusions

---

* *Use sand a gravel mixture, Do not buy colored gravel for aquarium. It is too light. Try it out before doing it in the class, to make sure it works. The important thing is to make sure particles are of different weights.*

DO WAVES HAVE ANY EFFECT ON DISSOLVED OXYGEN?

EQUIPMENT:
- Wave tank
- Rocks
- Oxygen Test Kit*
- Fan
- Spatula

PROCEDURE:
- Take the tank and build a rocky beach
- Fill about 1/2 with water
- Let it sit for 24 hours
- Measure dissolved oxygen
- Make summer waves for 5 minutes,
- Set up again and make winter waves

Fill in chart

Beginning D.O.	Summer D.O.	Winter D.O.	
			Trial 1
			Trial 2

---

* *Hach Test Kits are available from:*

Ward's Natural Science Est., Inc.
P. O. Box 1749
Monterey, Ca. 93940

See Reference 13

APPENDIX 10

WHAT EFFECT DO WAVES HAVE ON PLANTS AND ANIMALS?

EQUIPMENT: Plants and animals placed around the room

Suggested specimen:

Postelsia (palm kelp)
Limpets
Barnacles
Chitons
or any available specimen

PROCEDURE: Select at least one plantand one animal and look at it closely Write down all the things you can to show how it is adapted to live in the wave action area

	Plant (s)	Animal(s)
Flexibility		
Hold Fast		
Ability to Close up		
Other		

QUESTIONS: (suggested organism: ligia)

What factors limit these organisms?

a) Shifting sand
b) Abrasions
c) Pressure
d) Increase silting
e) Grazing life
f) others

PROCEDURE: Match the organisms below to their zone (low-low; low-high; high-low; high-high)

Mussell
Lidgva
Acorn Barnacle
Limpits
Blenny
Turban Snail
Lined Shore Crab
Common Sea Star
Rayed Star
Leather Star
Bat Star
Brittle Star
Purple Shore Crab
Cancer Crab
Aggregating Sea Anemone
Mossy Chiton
Octopus
Oyster
Rock Oyster
Sun Star
Giant Green Sea Anemone
Fish
Sponge
Nutibranch
Abalone
Peanut Worm
Flat Worm
Kelp Crab

PROCEDURE: Give the adaptations that permit the organisms below to live in their respective zones. (Eulittoral: attached to the bottom; Sublittoral: 50 - 200 m in depth)

Mussell
Lidgya
Acorn Barnacle
Limpits
Blenny
Turban Snail
Lined Shore Crab
Common Sea Star
Rayed Star
Leather Star
Bat Star
Brittle Star
Purple Shore Crab
Cancer Crab
Aggregating Sea Anemone
Mossy Chiton
Octopus
Oyster
Rock Oyster
Sun Star
Giant Green Sea Anemone
Fish
Sponge
Nutibranch
Abalone
Peanut Worm
Flat Worm
Kelp Crab

WHAT IS THE EFFECT OF WAVES ON THE SPRAY ZONE?

EQUIPMENT:
- Wave tank
- Rocks
- Spoon
- Bottle cap
- Fan
- Spatula

PROCEDURE:
- Set up tank with rocky shore
- Put a spoon or bottle cap in the dry area of the rocks
- Make winter waves

QUESTIONS:
1. Does any water splatter?
2. Where does the water go?
3. On the beach, in this zone, could any organisms live in these pools?
4. What problems would they have in surviving?

APPENDIX 12

WHAT IS THE EFFECT OF OCEAN WAVES ON MAN?

EQUIPMENT: Wave tank
Sand
Rocks
Wood

PROCEDURE: Set up tank with sandy shore at 45° angle to the direction of the waves.
Using rocks or blocks of wood, try to prevent the sand from moving
Describe your results

QUESTION: Are there any ways to prevent the sand from shifting?

PROCEDURE: Set up tank with sandy shore at right angles to the direction of the waves
Put a piece of wood on the sand to represent a house
Make winter waves

QUESTIONS:
1. What will happen to the house
2. What can be done

PROCEDURE: Using rocks or pieces of wood, try to prevent the shore from eroding

EVALUATION: Describe the results and conclusions

APPENDIX 13

WHAT IS THE EFFECT OF TSUNAMIS ON MAN?

EQUIPMENT:
Wave tank
Water
Three blocks of wood (one should be twice the size of other two)

PROCEDURE:
Place the three wood blocks floating on the surface of the tank of water
The large one should be in the center
Push down on the center block of wood with some force

QUESTIONS:
1. What happens to the two smaller blocks of wood?
2. Try to explain this
3. What would happen if the smaller blocks were islands?
4. What would happen if the smaller blocks were houses?

Discussion:
Surfing, fishing (grunion, smelt)
Breakwaters, Piers
Can man-made objects effect waves, shorelines, beaches?

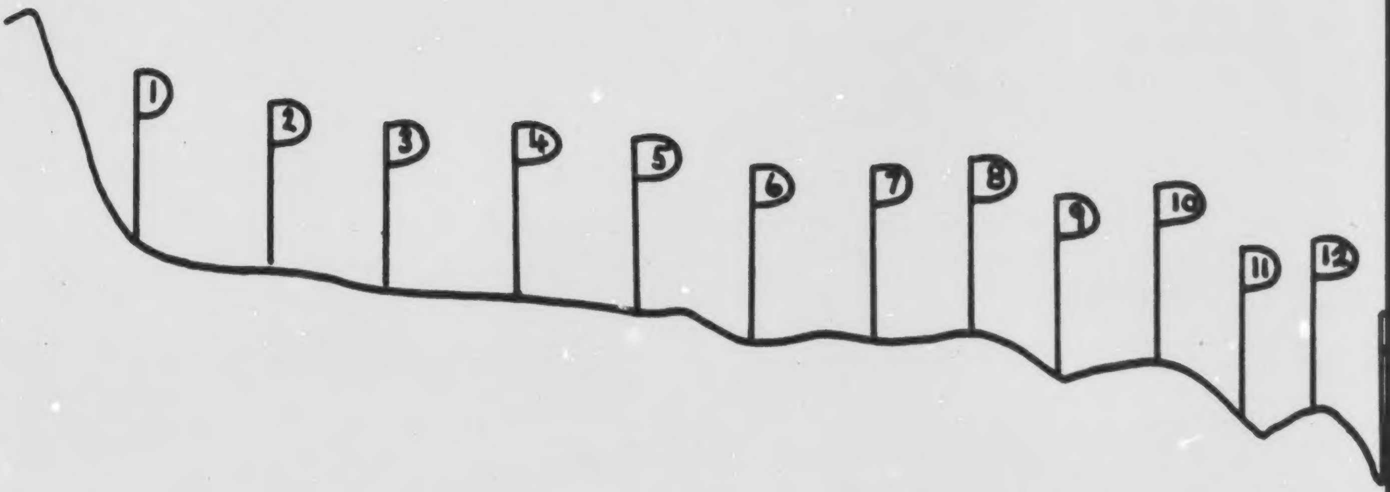
FIELD TRIP ACTIVITIES

1. Run a "line transect" from the shore to the low tidal area
   Divide into groups
   Begin by placing a stake at the base of a cliff
   Drive stakes into the sand (or sub-strata) at regular intervals
   from the cliff to the surf (low tide line)

   List below (under your station's flag) all plants and animals
   seen in a three-foot square (or cube)

   Count all species and populations and put them on the profile below

   For extra data: You might like to graph your findings.
   Where does one species leave off and another begin?



Note: Take depth and temperature of the water. Alternate teams, so each works in a sandy beach area, a zone two area and zone three and four.

FIELD TRIP ACTIVITIES

2. Measuring Wave Periods:
   - A. Choose an off-shore reference point
   - B. With the second hand of your watch, start timing when the crest of the first wave passes the rock and stop timing when the crest of the second wave passes the rock. The time intervals is the wave period. Be sure to identify the different parts of the wave.

$$T = \frac{L}{H}$$

3. Walk along the beach and find several pieces of driftwood. Throw a piece of driftwood in the ocean and watch its movement.

   What do you observe happening to it at first?
   What happens eventually to the driftwood?

4. Find a good point along the beach where you can see the waves coming in. Count the number of waves in a certain period of time. Look to see if you can group the waves into highs and lows. Count the number of high waves and the number of low waves for a full five minutes.

   How many did you count
   Where do the high waves break? Close to shore ______ , Far out _____

5. Find a good point on the beach where you can see the waves coming in. Make drawings or take pictures of the movements of the waves and figures they make on the beach (called cusps).

6. Place some colored sand right where the waves come in.
   Watch the colored particles and record what happens to them

GLOSSARY

BREAKER	A wave that breaks into foam
CREST	Top or highest part of the wave
CONFORMATION	A completed or symmetrical formation or arrangement
FETCH	The distance wind has blown
MOLECULE	The smallestbasic parts found in a given substance (gas, solid or liquid) - made of even smaller units called atoms
NEAP TIDE	The lowest tides which occur twice in each 30-day period (when the sun and the moon are at right angles to the earth, the oceans of the earth remain fairly constant in height along shorelines)
OSCILLATION	The natural "sloshing" or back and forth movement of water within a bay or basin caused by the rotation of the earth on its axis.
SEICHE	An oscillating or shloshing back and forth of an enclosed body of water
SPRAY ZONE	Area along the beach that is "sprayed" by the ocean waves
SPRING TIDE	The large upward movements of water caused by the combined pull of the sun and the moon on the earth bringing about the greatest vertical movement of water. Occurs when the sun and the moon are in line with each other, once every 14 days
SUMMER WAVES	Waves moved by a gentle wind toward shore
SURF	The region of breaking waves, including foam and spray, collective term for breaker
SWELL	A wave activity where there is no wind
TIDAL BORE	A great wall of water moving upstream, against the natural drainage of the stream or river into the sea, occurring where land inlets narrow sharply and where there are wide extremes between water levels at times of high and low tides (Tidal bores occur daily in the Bay of Fundy)
TIDAL WAVE	A term which is misued to describe giant waves caused by earthquakes or volcanic action. "Tsunami" or "seismic sea wave" are accurate and have now come into use
TIDES	The daily, weekly or monthly variations in the water level along the coasts or edges of continents caused by the gravitational effects of the sun and the moon on the earth
TROUGH	Lowest part of the wave between crests
TSUNAMI	A progressive gravity wave caused by earthquakes or underwater disturbances, commonly misnamed "tidal wave" often called seismic sea water. "Tsunami" is the japanese word for big wave
WAVE	General word for a curving ridge or swell in the surface of water
WAVE HEIGHT	Distance between trough and crest
WAVE LENGTH	Distance between each wave crest
WAVE PERIOD	The time in seconds for a wave crest to travel the distance equal to one wave length
WINTER WAVE	Storm wave caused by high winds blowing toward shore

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17. Shepard Francis, The Earth Beneath the Sea, Atheneum, New York, 1968
18. Thorson, Gunnor, Life in the Sea, McGraw Hill Book Co. New York, 1971
19. Weyl, Peter, Oceanography: An Introduction to Marine Environment, John Wiley & Sons, New York, 1970
20. Zottoli, Robert, Introduction to Marine Environments, C. V. Mosby Co., St. Louis, 1973

SUGGESTED FILMS

CC

6535	Waves on Water (16 min. color)
6516	Simple Waves (27 min.)
6547	Beach - The Arena of Sand (20 min. color)
6206	Restless Sea

MDUSD

FLS 707	The Beach IV: Formation of a Sand Spit
FLS 704	The Beach I: Source of Sand
FLS 705	The Beach II: Profile Study
FLS 706	The Beach III: Longshore Transport
FLS 708	Origin of Water Waves

TIDES

I. WHAT TIDES ARE

Upon completion of this unit, the student should be able to:

A. What causes tides?

state that the gravitational pull of the moon and sun causes tides and that the moon has more pull than the sun because it is closer to the earth

give the low and high tide at a specific location as well as the time and height by using a time table

Reference 1 *Appendix 1*

B. What affects tides?

select the correct factors when given a list of possible factors which could influence tides

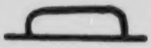
Factors affecting tides:

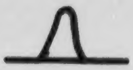
1. Gravitational pull of the sun
2. Gravitational pull of the moon
3. Rotation of the earth on its axis
4. Shape of the shoreline

Appendix 2

C. Where does the water go?

identify which of the following drawings represent low and high tide





Appendix 3

D. What are the various types of tides?

state in written form that

1. neap tides are small tides which occur when the moon is at right angles to the sun
2. spring tides are large tides which occur when the moon and the sun are in line with the earth
3. daily tides are two low and two high tides occuring daily
4. tidal bores are caused by the shape of the shoreline and are a large wave cause by the sudden rise of tidal water
5. a tsunami (tidal wave) is not caused by tides at all, but by a slippage of the earth crust (an earthquake)

E. How do you use a tide table

analyse and correctly use a tide table

Appendix 4 & 5

F. How do you correlate the moon-tide relationship?

complete a graph

Appendix 5

G. What is a tidal bore?

Appendix 6

II. HOW TIDES AFFECT THE EARTH

Upon completion of this unit the student should be able to:

A. Tides erode and wet the shoreline

Appendix 7

B. Tides mix and spread sediments and nutrients

state that tides take nutrients and sediments from the beach and spread them over a large area

Appendix 8

III. THE EFFECTS OF TIDES ON INTERTIDAL LIFE

Upon completion of this unit, the student should be able to:

list the adaptations that intertidal life has made to living in the intertidal zone.

They are:

1. resistance to drying
2. changing temperatures
3. changing salinity
4. changing wave action

Appendix 9

IV. TIDES AND THE FUTURE

Upon completion of this unit, the student should be able to:

A. Backflow

state that tides affect the point of mixing between a fresh water river and the sea

Appendix 10

B. list three possible uses the tides could be put to, and when given a proposed use will be able to give at least one possible effect the proposal will have on tidal life

Appendix 11

C. show that salt water incursion occurs when the flow of fresh water is decreased

Appendix 12

NOTE: See Appendix 13 for FIELD TRIP

APPENDIX 1

PLANETARIUM ACTIVITY

The sun's effect:

PROCEDURE: 1. Turn the earth so that the sun is making a high tide at San Francisco. Line up San Francisco with the sun and moon.

QUESTIONS: A. Where else is it high tide?
B. Is it high tide on the other side of the earth? -- Why?

PROCEDURE: 2. Turn the earth so it is now six hours later

QUESTIONS: A. Where is it high tide now?
B. Why are there two high tides during the day?
C. Why are there two low tides during the day

The moon's effect:

QUESTION: A. Which has the strongest pull on the earth?* Sun ___, Moon___

PROCEDURE: 1. Use the planetarium to show a spring tide, and a neap tide
Make a drawing

QUESTION: A. How often do spring tides occur each year?

* The moon has 2 1/2 times the pull of the sun

Reference 2, 3 & 4

NOTE: The planetarium consists of a sun that has the planet earth rotating about it, and the moon rotating around the earth. Most schools and district IMC centers have one.

APPENDIX 2

BEACH-TIDE RELATIONSHIP

EQUIPMENT:
Wave tank (wall paper tray works well)
Sand
Rocks or pieces of wood

PROCEDURE:

1. Set up the tank so that one end has a flat, sandy beach
   Raise the water level in the tank four inches
   Measure the distance the water moves up the beach

2. Make a cliff beach. Use either rocks or pieces of wood
   Raise the water level four inches
   Measure the distance the water moves up the cliff

QUESTIONS:

1. On which beach would the organisms be most dependent on the tides?

2. On which beach would the tides appear to be rising the most?

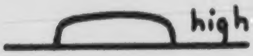
3. Which beach would have the most mixing of the nutrients?

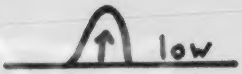
APPENDIX 3

HIGH AND LOW TIDES

EQUIPMENT: Silly putty
Bowl

PROCEDURE: Take the silly putty and drop (plop) it on the table
the shape the putty makes represents high tide on the shoreline





Pull up the center of the putty making a peak. This represents the pull of gravity from the moon and sun
This shape shows low tide on the shoreline

QUESTION: What happens to the water at low tide?

PROCEDURE: Take the bowl and slosh the water back and forth, so it goes up one side and down the other.

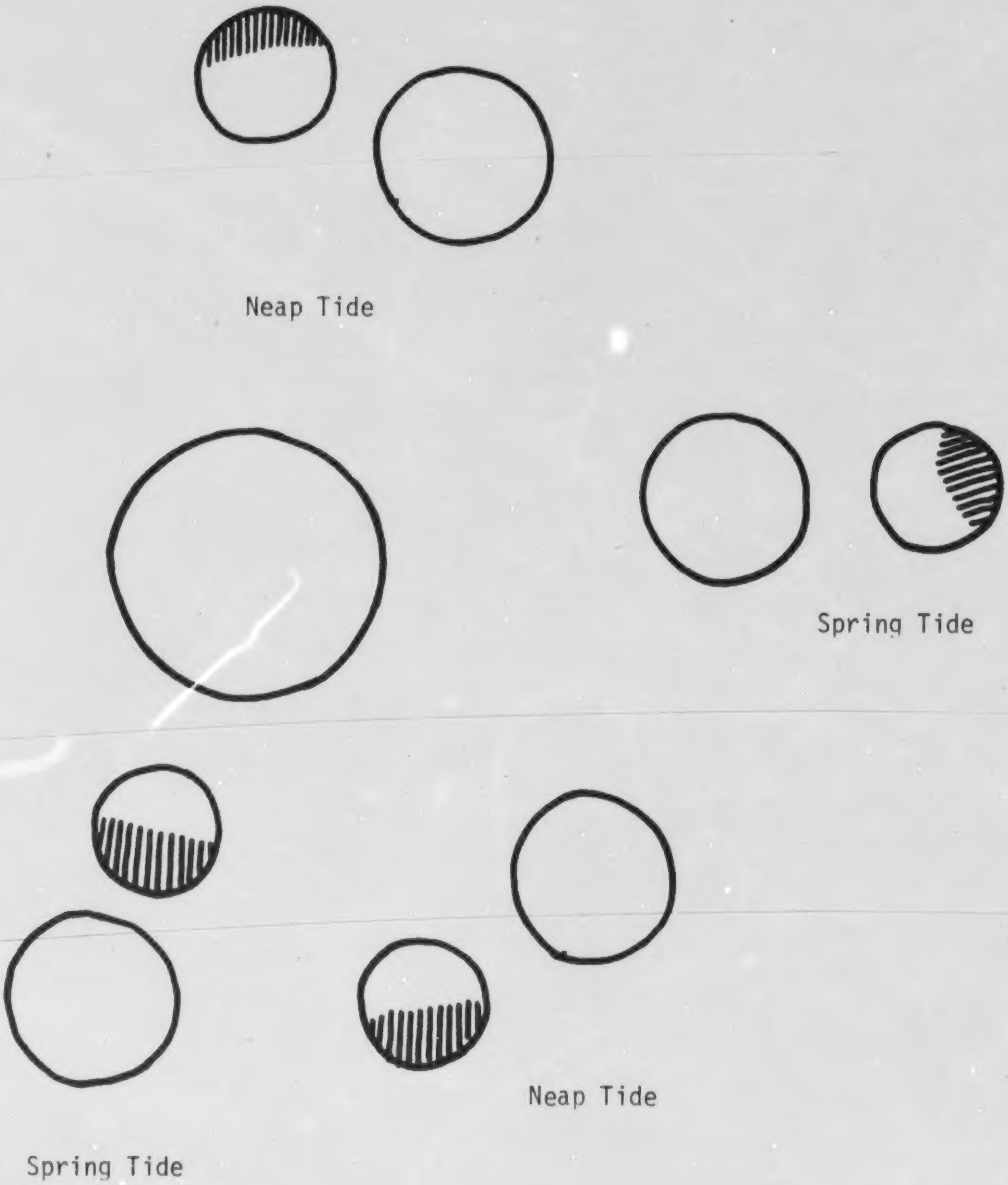
This is called seiching and occurs in large lakes
This is not how tides are formed.

APPENDIX 4

TYPES OF TIDES

EQUIPMENT: Use the planetarium to find:

Spring tides and neap tides


Neap Tide
Spring Tide
Neap Tide
Spring Tide

NOTE: For daily tides repeat parts of the planetarium demonstration (Appendix 1)

USING A TIDE TABLE

EQUIPMENT: A class set of tide tables (available at sporting goods stores)

QUESTIONS: 1. Looking at the tide table, how do you know a minus tide?

____

a) How many tides are there in one day? Make a guess _____

b) Why ______________________________________

2. Look carefully at the tide table for __________(month)

a) What day has the lowest tide? ________________________
(indicate day of the week, date, time, a.m. or p.m.)

3. b) What day has the highest tide? ________________________
(indicate day of the week, date, time, a.m. or p.m.)

4. We will be going on our field trip on ____________(date)

a) What time is the lowest tide _________________________

b) How low is it? _____________________________________

5. The tide table you have been using is for high and low water predictions for the San Francisco Bay. A correction table is necessary if you are going somewhere else. Flip through your table and find the Correction Table. On our field trip we will be going to _____________________________________(place)

a) What is the correction time? ________________________

b) What is the correction in feet? ______________________

6. Knowing this you can now figure out the correction factor for our field trip.

a) What time will low tide be there? ____________________

Reference 5 & 6

MOON-TIDE RELATIONSHIP

PROCEDURE: For a two months period, using the reference provided, draw the phases of the moon for each seven days.

Graph: Moon Phases

QUESTIONS:

1. Can you see any relationship between moonphase and tide?
2. Why are people interested in tides?
3. Why are organisms interested in tides?

APPENDIX 6

TIDAL BORES

EQUIPMENT: Wave tank
Sand
Beaker
Rock

PROCEDURE: Put two inches of water in the wave tank
Using sand, make a long, narrow inlet, approximately 2" wide

QUESTION: How does this demonstrate a tidal bore?

PROCEDURE: Use the wave tank, drop a large rock into the water in the tank

QUESTIONS:

1. How does a tidal bore differ from a tsunami?
2. How does this demonstrate a tsunami?
3. How different is a tsunami from this demonstration?

Review Appendix 13 and the glossary in WAVES on tsunamis, using blocks of wood.

APPENDIX 7

EFFECTS OF TIDES ON THE BEACH

EQUIPMENT: Wave tank or stream table
Sand

PROCEDURE: Make a gradually sloping beach in the wave tank or stream table
Gradually raise and lower the water level in the tank
Make no waves

QUESTIONS:
1. How would you do this?
2. List two effects you can see that the "tide" has on the beach

APPENDIX 8

THE EFFECTS ON PARTICLES IN TIDE ACTION

EQUIPMENT: Wave tank
Sand Particles of different weights (beach is the best place to get them)
Food coloring

PROCEDURE: Make a gradually sloping beach out of at least two different weight particles. Slowly raise and lower the water level
Be sure not to make waves

QUESTIONS: Describe and draw a picture of your results after 5, 10 and 15 minutes

Does the tide action separate sand particles?

PROCEDURE: Make a gradually sloping, sandy beach. Add two inches on water
Place some food coloring on the sand in the "intertidal" zone
Make several high and low tides
Be sure not to make waves

QUESTIONS: Describe and draw your results after 5, 10 and 15 minutes
Discuss your findings
If the dye was a nutrient that organisms depend on, would the tide be helpful to the organism?

TIDAL ZONES

EQUIPMENT: Flannel board or live or preserved specimen

PROCEDURE: On a flannel board or chalk board, draw the tidal zones

BACKFLOW

EQUIPMENT:
- Wave tank
- Salt
- Rubber tubing
- Epoxy glue
- Food coloring (red and blue)

PROCEDURE: Using the wave tank make a drain at one end by drilling a hole in one end of the tank, the size of a piece of rubber tubing. Put the rubber tubing in the hole, seal the hole with glue. Be sure to seal both sides of the hole tightly, or it may leak.

Add continuously red salt water and adjust the rate of flow so that a constant level is maintained. At the other end add a continuous stream of blue tap water. Maintain the flow of each so that a constant level of water is present.

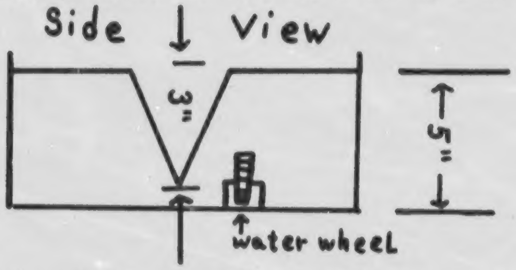
Mark the spot where the two waters mix. Cut the flow of salt water (red) to one half of the original flow.
Mark the spot where the mixing occurs now.
Double the amount of salt water flow and mark the spot where the mixing occurs.

Trial	Original spot measured from the left side	Approx.1/2 times salt flow (low - tide)	Approx.two times salt flow (high - tide)
1			
2			
3			

POSSIBLE USES OF TIDES

EQUIPMENT: Wave tank
Piece of wood
Water wheel (available in aquarium store)

PROCEDURE: Place a piece of wood across the tank to make a "tidal wall"



Place a water wheel under the wall. Raise the water on the tidal side to four inches and maintain a four inch height. Have a drain open on the shore side (the water should spill over the spillway on the water wheel)

QUESTIONS:

1. Could this technique be used to generate electricity in the ocean?
2. Why or why not
3. What effect would this have on the shorelife?
4. List at least three other ways in which tides could be used for energy production, food or anything else
5. Include potential bad effects that could occur

BACKFLOW

EQUIPMENT: Wave tank (equipped as in appendix 10)
Salt
Food coloring (red and blue)

PROCEDURE: Using the wave tank equipped with a drain add red salt water continuously and adjust the rate of flow so that a constant level is maintained. At the other end add a constant stream of blue tap water. Maintain the flow of each of that a constant level of water is maintained.

Mark the spot where the two waters mix.

Increase the flow of the blue (fresh) water. Mark the spot where the mixing occurs now.

Decrease the flow of blue (fresh) water to less than the original flow. Mark the spot where the mixing now occurs.

RESULTS:

Trial	Original Point of mixing distance from left	Increased fresh water flow distance from left	Decreased fresh water flow distance from left
1			
2			
3			

QUESTIONS:

1. What happens as less fresh water is allowed to flow down the Sacramento River to our Delta?
2. To our drinking water?
3. To organisms living in the water?

FIELD TRIP

PROCEDURE: Make a line transect starting at the water edge and list the organisms found.
Continue your transect to the high tide level

QUESTION: 1. What organism did you find the most of at low tide?

PROCEDURE: Set up a camera (use a 35mm or better yet a 8mm movie camera) on a tripod. Place a marker at low tide and take pictures at a set time interval (every 5 min for 8 mm and every 15 min. for 35 mm)

Select an organism and tell all you can on how it is adapted to living where it does.

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   A teacher reference only
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   A student reference
5. Rabinowitz, Alan, Oceanography: An Environmental Approach to Marine Science New Jersey Oceanography, Unlimited
   A teacher reference only
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SUGGESTED FILMS:

cc 2526, Tides, 10 min. B/W

cc 5015, Ocean Tides, 14 min. Color

OTHER AIDS

MDUSD FLS 695 The Tidal Pool - Variety of Animals

SD 449, Tide Pool Marine Life

INTRODUCTION

This section on currents is intended to be a part of a series on Waves, Tides and Currents. It is hoped that your students will have covered the material on waves, tides and hydrologic cycle as these concepts are necessary for them to be able to understand fully the physical and chemical properties of water.

In addition to the parameters listed above, a basic introduction to soils and weather is desirable in order to fully understand the life that exists under specific conditions of weather, water movement, water quality and substratum.

CURRENTS

MAJOR OBJECTIVES:

Upon completion of this unit the student should be able to explain:

I. What a current is, and how currents move.

II. How man discovered ocean currents and how he has used them.

III. What the effect is, of currents upon shore lines and ocean basins.

IV. What the effect is, of currents upon nutrients in the water.

V. What the effect is, of currents upon the economy of man.

VI. The correlation of the above findings (re. the ocean) to the complex of the Bay-Delta-Estuarine system.

CURRENTS

I. WHAT IS A CURRENT AND HOW DO CURRENTS MOVE?

The student should be able to:

A. Discover and observe that the total depth (or volume) of a given body of water, such as an ocean, bay or river, is moving in some direction or current.

Reference 2 - "Waves, Tides and Currents" pp. 65-70
Reference 11 - "Let's Explore the Ocean" pp. 15-19

B. Observe by experiments that this larger body of water moves in surface currents and in deep water currents, and that these movements are similar to the flowing of rivers.
Note: This objective will be fulfilled in the series of activities listed below.

Reference 2 - "Waves, Tides and Currents" pp. 68-70
Reference 7 - "The Sea" pp. 76-77
Reference 15 - "How and Why of Oceanography" pp. 22-25

C. Identify the four basic causes of currents:

1. Heat from the sun pulls water out (up) into the atmosphere.

   See Appendix 1

2. Winds blowing in two prevailing directions (trades or westerlies) carry (or push) the water in their direction of progress.

   See Appendix 2

3. Rotation of the earth on its axis creates a 'correolis' effect (swings water in a gyral or broad arc) circling clockwise in the Northern Hemisphere and counter-clockwise in the Southern Hemisphere.

   See Appendix 3 & 4

   Reference 7 - "The Sea pp. 76-78
   Reference 11 - "Let's Explore the Ocean" p. 14

4. State that the combination of these factors keep water moving around the earth.

D. Demonstrate that cold dense water sinks and flows on the bottom of the ocean, and that warm, less dense water rises and flows on the surface,

1. Construct an experiment to show that where warm and cold water currents meet, there is first a mixing of the two waters and then an upwelling or rising to the surface of the colder water.

   See Appendix 5

2. Further observe that the cooled water will again sink to the bottom and flow under the warmer water which rises to the surface.

See Appendix 6 & 7

3. Further observe a mixed layer (thermocline), at least recognizing it by color, between the warm and cold layers, and to state that this is an area of temperate climate.

See Appendix 7

4. Demonstrate that currents move faster on the outside (rim) of a gyral, than in the center (hub).

See Appendix 8 (Fact Sheet)
See Appendix 9

Reference 7 - "The Sea" pp. 75-80

II. HOW DID MAN DISCOVER OCEAN CURRENTS?

The student should be able to:

A. Describe how man discovered ocean currents and how he used them for transport.

Reference 7 - "The Sea" pp. 76-79
Reference 11 - "Let's Explore the Ocean" pp. 18-19

B. Draw the major currents of the world on a flat world map.

See Appendix 10-

C. Recognize and draw the counter-currents in the Atlantic, Pacific and Indian Oceans.

See Appendix 10-

Reference 2 - "Waves, Tides and Currents" pp. 66-67
Reference 8 - "World Beneath the Oceans" pp. 88-89
Reference 16 - "Exploring the World of Oceanography" pp. 14-15

III. WHAT IS THE EFFECT OF CURRENTS ON SHORELINES AND OCEAN BASINS?

A. Draw the major ridges, rises and shelves (ocean bottom topography) on a flat world map.

See Appendix 11

Reference 7 - "The Sea" pp. 64-73
Reference 8 - "World Beneath the Oceans" pp. 28-29

B. Know how to construct (and physically do it, if possible) in the stream table a topographic design of an ocean or bay basin with its coastline.

See Appendix 12

See above References on "ocean floor"

C. Be able to demonstrate current flow on the model and describe how it is affected by the bottom topography and coastline.

D. Hypothesize on how beaches and shores might be affected by variances in currents.

NOTE: Discussion with team-mates and instructor on material learned at this point.

IV. WHAT IS THE EFFECT OF OCEAN CURRENTS ON NUTRIENTS IN THE WATER?

A. State the effects of currents on plants and animals that live in ocean or bay waters. (This is intended to be only a general hypothesis and not by measurement or chemical analysis)

B. Draw, or state how the upwelling of currents brings nutrients to the surface to feed larger animals.

Reference 3 - "This Great and Wide Sea" pp. 130, 131; 140-142; 158-
Reference 5 - "Phytoplankton, Grass of the Sea"
Reference 7 - "The Sea" pp/ 78-79; 84-85; 105-111
Reference 10 - "The Chemistry and Fertility of Sea Waters pp. 10 & 99
Reference 11 - "Let's Explore the Ocean" pp. 59-69
Reference 13 - "The Sea, A New Frontier" pp. 13-21

V. WHAT IS THE EFFECT OF OCEAN CURRENTS ON THE ECONOMY OF MAN?

A. Observe, at first hand, how currents have actually changed shores and harbours and hypothesize how this has affected the economy or land-use of the area.

Field Trip: Half Moon Bay, Princeton Harbour
(talk to Harbour Master, observe
complete change in movement of
beach, effects on the people there)

B. Describe how waste materials dumped into the ocean could ultimately be carried by currents to food producing areas and destroy the food chain.

Reference 4 - "The Living Sea"
Reference 9 - "Uses of the Seas" pp. 62-98

VI. FOR ADVANCED STUDIES

A. Be able to correlate all (or any part) of the above findings to the Bay-Delta-Estuarine Complex.

B. Be able to test laboratory observations in a real situation by (having been given proper equipment, i.e. Nansen or Van Dorn bottle) taking samples of water from the surface, mid and bottom depths and compare their density by salinity tests. (MER manual method)

C. Be able to do the same to compare temperatures.

D. Hypothesize that surface currents run faster than deep water currents.

E. Test student current speed hypothesis by lowering a current meter into the water and recording bottom, mid and surface readings. Compare RPM's at the three sampling levels.

F. Collect plankton at the three levels and correlate their population to to the speed, temperature amd density of the current.

Field Trips: (to any of the following locations)

For Wharf - Shore: Half Moon Bay - Princeton, Martinez Boat Harbour, Pittsburg Boat Harbour, Berkeley Marina, Richmond Shore and Pescadero Coast or Point Molate (MER Station)

For Boat: Redwood City "Inland Seas" (Oceanographic Research Vessel), Pittsburg Harbour (Mt. Diablo Research Vessel), Upper Delta by boat or drive to Jersey Island, take ferry (Call Jack Freitas, Brentwood)

APPENDIX 1

ACTIVITIES - CURRENTS

WHAT CAUSES CURRENTS?

In the four circles at the right, DRAW by using arrows, the four major causes of ocean currents.

Reference 7 "The Sea" pp. 76-66
Reference 15 "How and Why of Oceanography" pp.22.26

1. What force would be acting upon the earth in drawing 1, to make it look bulged out in the center? ______________________________

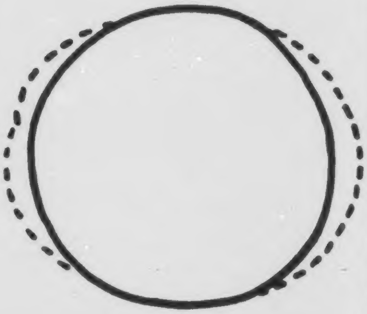
2. Does the sun heat the water at the poles as much as it does at the equator? ___________
Partly at one? _____, Not at all at one? _____

3. What are the two major prevailing winds?
__________________, ______________________
Show their direction on globe 2, using arrows.

4. What did you just learn in your experiment on the record player, that causes oceans to circle in gyrals? Write it under globe 3.
Show proper direction.

5. Draw in globe 4, what direction the currents take when ALL of the first three forces are working on them.

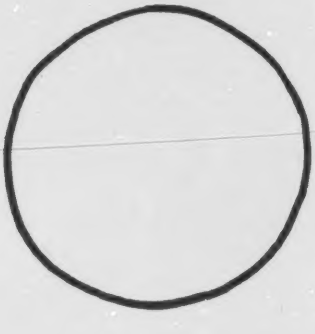
5. There is also a 5th (fifth) and very important factor affecting currents.
What would that be?_____________________
Explain it here. _______________________
____
____



1. ____________________

2. ____________________

3. ____________________



4. ____________________

ACTIVITIES - CURRENTS

To demonstrate heat from sun pulling water out (up) into the atmosphere.

EQUIPMENT:

1. Two packages of 'silly putty' blended together
2. A simple planetarium of the earth-moon-sun, mounted on a rotating base.

PROCEDURE:

1. Have a short discussion to relate sun's heat pulling water up - to the experiment on hydrologic cycling where students observed that the heat caused liquid water to change into vapor and rise into the air. (If necessary, repeat this experiment to re-enforce the idea)

2. For a simple experiment to show gravitational pull -
   Let student take the 'glob' of silly putty' ......
   Throw it on the table.
   Pull up the center of the mass. Observe
   LET GO of the mass. Observe

QUESTION:

1. Compare the action of the silly putty to the sun's gravitational pull and release of ocean waters, as the earth rotates.

2. Move the planets on the planetarium in the proper direction and 'check out' how this pull would affect current flow.

NOTE: Further discussion and experimentation on this concept will come up again in later experiments.

ACTIVITIES - CURRENTS

To demonstrate the principle that wind drives water in currents.

EQUIPMENT:

1. Round basin (half full of water) with equator drawn along the center of the base and 'poles' marked on the opposite sides.
2. Student-made boat of paper, plastic or whatever.
3. Plastic tubing 1/2" x several feet.
4. Fan
5. Fireplace bellows?
6. Vacuum with hose attachment.

PROCEDURE:

1. Student can simply blow on boat to observe its course around the basin.
2. Further activity could include blowing through plastic tube.
3. Using the fan or bellows, changing the wind direction.
4. Using blower attachment of vacuum for greater force.

OBSERVE

QUESTIONS:

1. In open discussion with your team, analyse the direction of progress of your boat(s) from your different 'wind' sources and how it was deflected (bounced off the sides of the basin, (could the sides of the basin represent continental land masses?)
2. What direction did the boat go, after hitting the land mass?

   ____

3. As you blow wind on your water, does the current you set up run toward the equator, or toward the poles? ____________
4. What if there were NO land masses to deflect the currents?

TO TEACHER: *Let students come up with own creative ideas for ways to demonstrate wind-driven currents.*

See also activity Appendix 3 using the water basin on the record turntable to try out any of the above ideas on a rotating basis.

ACTIVITIES - CURRENTS

To demonstrate the principle of the 'coriolis' effect; that water moving on a rotating surface will move in gyrals (arcs).

EQUIPMENT:

1. Record player
2. Piece of chalk
3. An OLD record (clean)

PROCEDURE:

1. Place record on turntable
2. Turn player at 78 RPM's
3. Take the chalk and try to draw a straight line from the center of the record player toward yourself.
4. Stop the player and observe

QUESTIONS:

1. What is the shape of your line? ____________________
2. What does this prove? ____________________

   ____
3. Does it make a difference if you slow down the speed? ____

   Try it. Describe the results ____________________

   ____

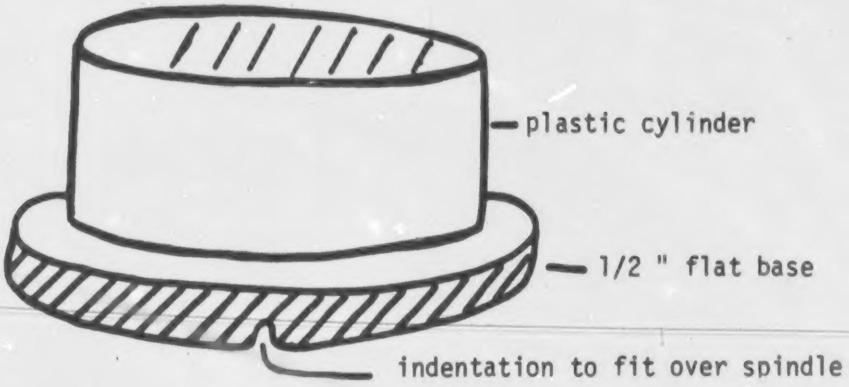
   ____

ACTIVITIES - CURRENTS

To demonstrate the principle that the 'coriolis' effect circulates currents in gyrals.

EQUIPMENT:

1. Round bowl made of clear plastic
2. Have a ring (tube) of clear acrylic plastic cut from a cylinder about 9" diameter x 1/4" thickness x 4" deep
3. Cut a larger ring of flat acrylic 12" diam. x 1/2" thickness
4. Drill a 1/4" indentation into the exact center of the base
5. Bond 9" ring onto center of top side of flat base, using acrylic bonding seal. See diagram below.
6. Record player with turntable
7. Cut a sheet of opaque white plastic the same size as the record turntable, and place upon the turntable firmly. Place the acrylic basin upon the spindle. (The opaque base should make it easier to watch the current movements)



PROCEDURES:

1. Place acrylic bowl on record turntable
2. Fill bowl about half full of water
3. Turn record player at 33 1/3 RPM, then 45 RPM, then 78 RPM
   a. Observe the movement of the water
   b. Describe it

QUESTION:

1. Would the movement observed represent the gyraling in the Northern Hemisphere?

NOTE: *See Appendix 4 and 5 for further activites using this equipment.*

ACTIVITIES - CURRENTS

To demonstrate that variances of temperature and density determine the level (or depth) at which currents will flow.

EQUIPMENT:

1. Use the same round bowl on the record turntable as in Appendix 3
2. Plastic tubing 1/2" x several feet
3. Plastic funnel
4. 400 ml. beaker half full of ice-cold, blue salt-water
5. 400 ml. beaker half full of warm, yellow, fresh-water

PROCEDURE:

1. Place bowl on record turntable and set speed at 33 1.3 RPM's
2. Set funnel into one end of plastic hose
3. Set other end just under the surface of water in bowl
4. Pour dense, blue solution through tube into moving water

   OBSERVE
5. Pour fresh, warm water solution through tube into water - just under the surface

   OBSERVE

QUESTIONS:

1. What happened to the dense water? ______________________________
2. Did it stay on top, or sink to the bottom? ______________________
3. What happened when you added the warm water? ____________________

   ____
4. When a cold water current flows under a warm water current toward the equator, does the water become the same temperature throughout? __________
5. Does this slow the current, or stop it? ______________
6. Which has the greatest velocity (speed) warm water ____ cold ____

   Why? ____

   ____
7. If the bottom currents are so dense (heavy) as to remain on the bottom, while circulating so slowly do they remain on the bottom and mix with bottom currents of other oceans, OR do they rise to the surface as they approach the equator?
   Discuss this in your group.

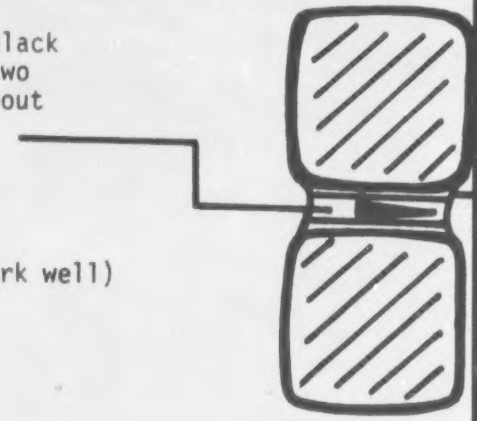
APPENDIX 5

ACTIVITIES - CURRENTS

Construct an experiment to show that where warm and cold water currents meet there is first a mixing of the waters and then an upwelling or rising to the surface of the colder water.

EQUIPMENT:

1. A set of four double pint jars (peanut butter jars work well since they have a rubber liner inside the lid to help prevent leakage)
2. In the center of each lid, cut a 1" x 1" square hole so that they are in the exact spot in each lid
3. Using black plastic electrical tape, tape the two lids together back to back, so that you can screw the two jars into the lids
4. Cut a strip 1 1/2" x 3" (appr.) from the center of the top of a cottage cheese carton
5. Cut a slot in the center of the black tape (so that it is between the two lid tops). This cut should be about 1 1/2" wide, or slightly more to facilitate sliding the plastic card in and out.
6. Container of salt
7. Food coloring (blue and yellow work well)
8. Glass stirring rod
9. Ice cubes - a large bowl
10. Hot plate
11. Extra (large) plastic bowl



PROCEDURE:

1. Insert the plastic card into the center of the slot in the bound lids
2. Fill each jar with one of the various solutions listed below
3. Seal the lid very firmly on the first jar, before inverting it to screw the other jar onto the opposite side of the lid
4. Proceed with projects listed on next page

NOTE: this experiment should be set up with enough jars to run an inquiry for a group of 4 - 7 students at one time.

Have them all prepare their set-up, then pull out their cards to time their project from the same moment.

This could lead to a great group discussion (debate)

To save time one student could mix up salt solution for the group.

ACTIVITIES - CURRENTS

Series of possibilities for this project:

Fill each of the set of jars with one of the set of solutions

Fill	BOTTOM JAR	TOP JAR
	1. Ice water, 1 teasp. salt blue color	Hot water, no salt, yellow color
	2. Ice water, 1 teasp. salt blue color	Hot water, 1 teasp. salt, no color
	3. Ice water, 1 teasp. salt blue color	Tap water (room temp), no salt yellow color
	4. Ice water, 1 teasp. salt blue color	Tap water (room temp), no salt no color

Remove the card from the center of each one and OBSERVE
(Before you do this, hypothesize what might happen)

VARIATION 5. Set up each of the above, invert the double jars, pull out the cards and observe.

QUESTION Is the movement of the waters different in any case? ____________

How? ____

VARIATION 6. Time the total movement of each set of liquids.

QUESTION What did you observe? ______________________________

____

____

VARIATION 7. Set the bottom jar (with ice water) into a bowl of ice

8. Reverse any one of them and set in a bowl of very HOT water

9. Place any one of the projects in a horizontal position and observe the results.

QUESTIONS

What were you looking for in each case?

Did the results verify your hypothesis?

What general conclusions could you draw from watching and timing your projects?

Discuss it as a group.

ACTIVITIES - CURRENTS

Further observe that the cooled, or cold water will again sink (overturn?) to the bottom and flow under the warmer less dense water which rises to the top.

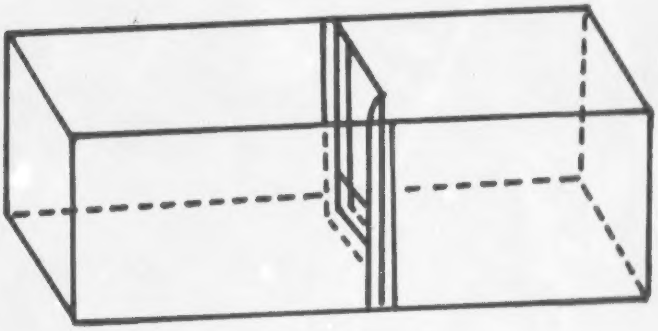
EQUIPMENT:

1. A 5 or 10 gallon tank

   Make a groove in the center of the tank by gluing 1/4" strips of acrylic, running from the top of one side of the tank, down and across the bottom, and up the opposite side to the top.

2. A square sheet of plastic cut to fit the groove exactly*

   NOTE: You may also want to cut the top surface of this sheet in a curve, to show over-flow. The top of the curve should be no higher than the top of the tank, or even a little bit lower.



PROCEDURE:

1. Set divider plastic into place in the groove
2. Fill one half of the tank with ice-cold salt water, colored blue. (If using a curved top divider, fill only up to the base of the outer edge of the divider sheet.
3. Fill the other half of the tank with hot, yellow tap water, with no salt added - to the top of the curve. OBSERVE

QUESTION: What happened? ______________________________

____

4. Wait a few minutes, while observing.
5. NOW pull the divider all the way up Observe closely.

   Describe the over-all action ______________________________

   ____

   ____

* See Appendix 7 for an experiment not requiring the sliding sheet of plastic.

APPENDIX 7

ACTIVITIES - CURRENTS

Further observe a mixed layer (or thermocline) between the warm and cold layers (by color) and to state that this is an area of temperate climate.

EQUIPMENT:

1. Use the same tank as for the experiment in appendix 6, only remove the divider. Fill half full with clear tap water.
2. Have ready: a) 400 ml. beaker of ice water
   add 1 tbl. salt
   blue color (stir until all salt is in suspension)
   b) 400 ml. beaker of HOT water
   no salt
   yellow color

PROCEDURE:

1. Have one student pour dense, cold water into one end of the tank.
2. Have another student pour hot, less-dense water into the other end of the tank.
3. Have students observe, from eye level.

QUESTIONS:

1. What happens? ____________________
2. Could you relate (compare) this observation to what goes on in the ocean? -- Discuss with group.
3. In which layer would you expect to find the most abundant life?
   __________, Why? ____________________
4. How might this affect food populations in the ocean? -- and the human harvesting of it? ____________________

EXTRA EXPERIMENT:

When two variant currents meet, how would the atmosphere be affected?

Would you have fog? ____ Why? ____________________

Place ice cubes or small block of ice in your cold water current - After adding hot water current, place a sheet of glass over the tank and observe. Tie-in to hydrologic cycle.

FACT SHEET *APPENDIX 8*

CURRENT SPEED - VELOCITY

Reading for student - prior to velocity experiments

FACTS ABOUT OCEANS -

All oceans are connected. If you doubt this, just look at any globe or map of the world.

NOW - think of your hydrologic cycle. Water is always moving in some way. Wonder where the water in your bath comes from? Has it also washed seals in Alaska - carried along fish in Canada - watered forests in California ? -- To drain into 'our' Delta - to be filtered by your Water District - so YOU can drink it - bathe in it - swim in it - only to let it go down the drain again - back to the Bay - out to the sea - to flow down to the equator - up the Kuroshio current - back to Alaska - to wash the seals - to ....

HOW LONG would all that journey take?

Did such a cycle begin hundreds of years ago?

*** Will the water that you are working with today EVER be the same again.

BY THE WAY ....

Did you know that the word current comes from the French word currere, meaning to RUN? - This is why oceanographers refer to currents as running like rivers in the sea.

Let's see if we can find out anything about current velocity (speed)!

First - little historical side-light might help:

There is an area in the Atlantic ocean called the Sargasso Sea. It was a problem to early sailors who felt that a ship stranded in the heavy mat of sargasso weed there would float there forever, unable to get out. Actually, this mat of sargasso weed was simply smaller mats or patches, about the size of doormats and not even thick enough to catch and hold a ship.

What was really finally determined was that the water (being the 'hub' of a gyral) was almost motionless.

Because of almost a lack of water movement here, there is almost no life existing under the seaweed; since no new water is entering the hub, it is not bringing fresh nutrients.

ACTIVITIES - CURRENTS

To demonstrate that currents move faster on the outside of a gyral (rim) than in the center (hub).

EQUIPMENT:

1. Any kind of a wheel (Tire, Wagon wheel, Wheel cut out of plastic, etc.)
2. Map measurer (get from Army surplus store)

PROCEDURE:

1. Make a mark on the rim of your wheel. (This will be your reference point)
2. Set the wheel at its' reference point, on the floor or table and turn the wheel 360°. Mark this end point on your surface.
3. Run your map-measurer along this course and record the distance and time below.

   D__________________, T__________________

4. Now, lay the wheel on its side, and run your map-measurer around the hub. Record time and distance below.

   D __________________, T __________________

   Compare the difference.

QUESTION:

How much longer would it take water to flow around the rim of your wheel, (gyral) - than around the hub? __________________

On the speed of currents:

EQUIPMENT:

1. Use the same bowl on the record turntable as in Appendix 4.

PROCEDURE:

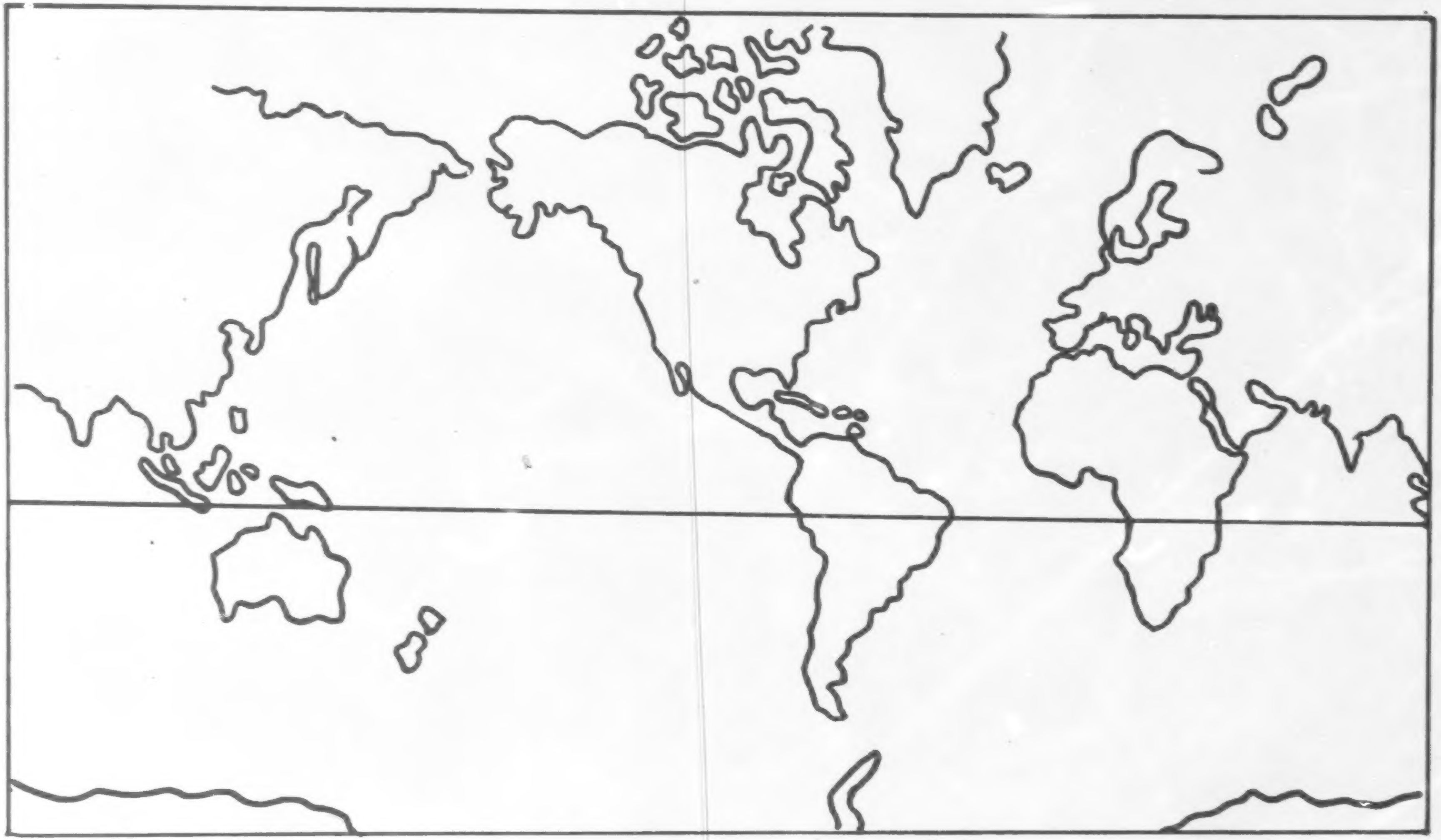
1. Mark a spot on the side of the basin
2. Set your boat on the water, near the edge of the 'gyral'
3. Turn record player on 33 1/3 RPM's
4. Time speed of boat making one complete revolution
5. Now, place boat in center of 'hub' - center of bowl
6. Time speed of one rotation (complete rotation of the boat)
7. Compare the two speeds

QUESTIONS:

1. Does the outside of the gyral move faster than the hub? _______
2. How much faster? ______________________________
3. Do you think surface water would mave faster or slower than deep water? _____________
4. How could you test your hypothesis? __________________________

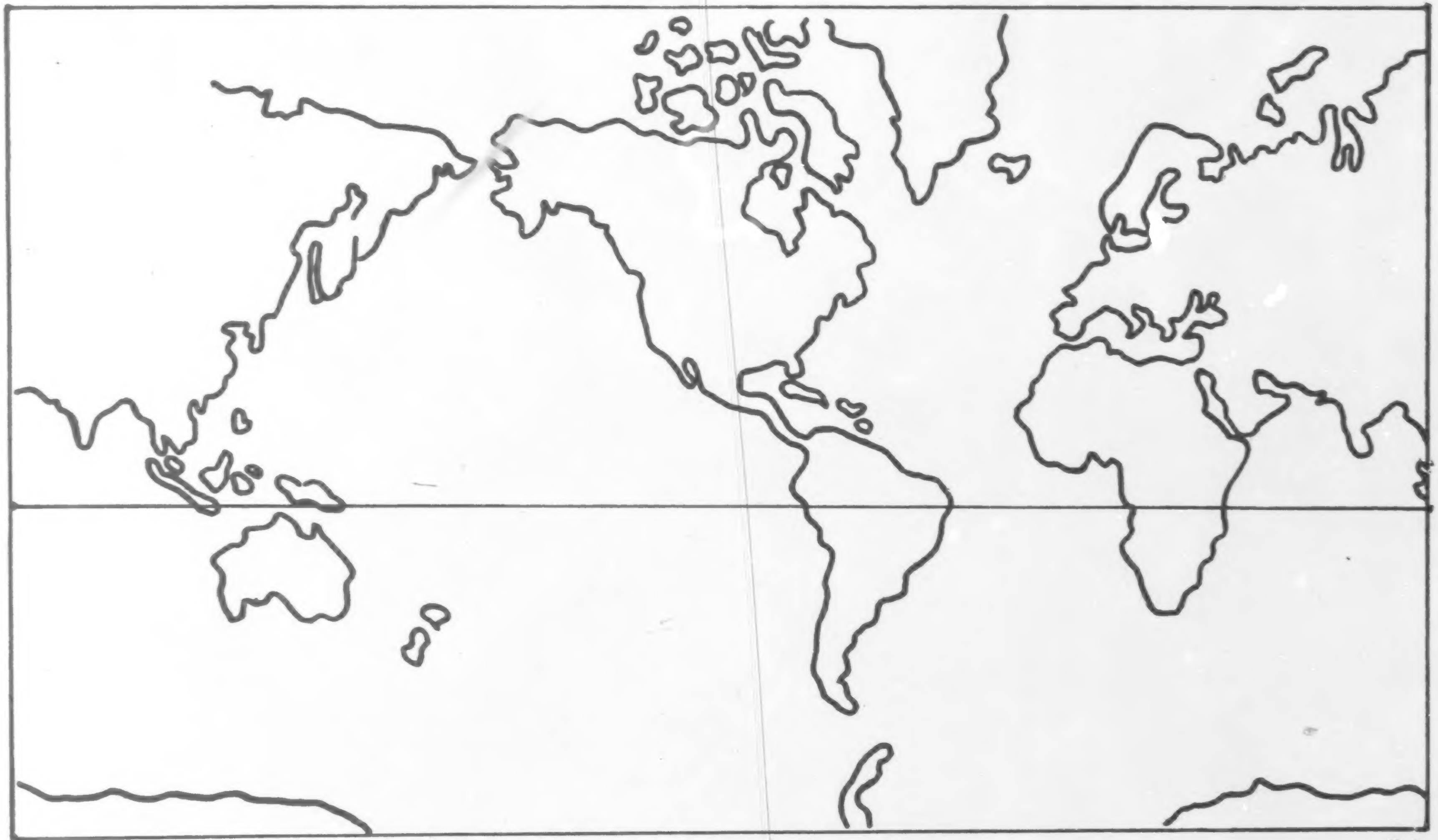
APPENDIX 10

OCEANOGRAPHIC WORLD MAP



Draw in the major currents of both hemispheres. (Use arrows to show direction)

OCEANOGRAPHIC WORLD MAP



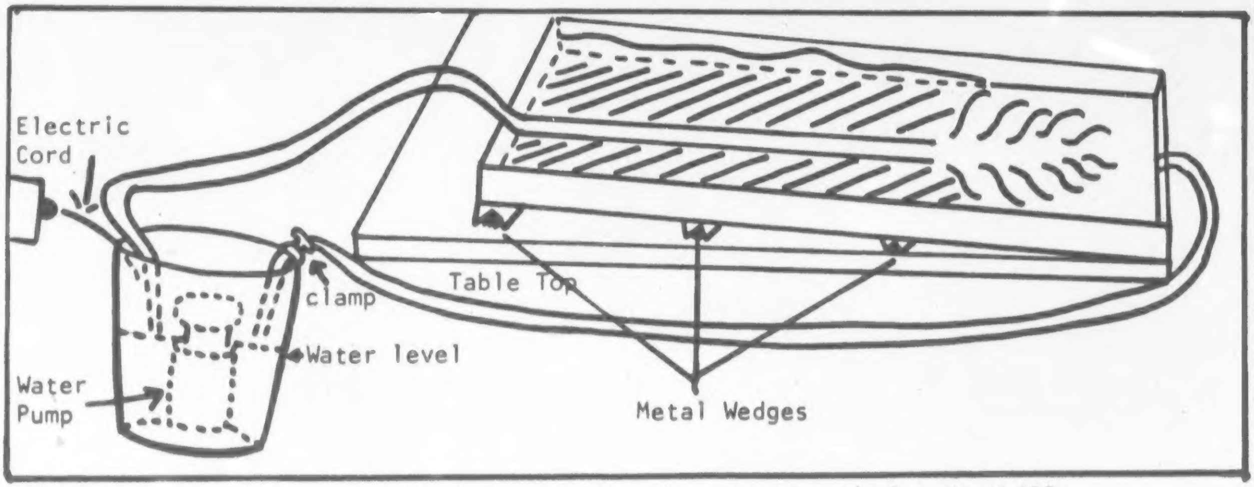
Draw in the major ridges, rises and shelves.

APPENDIX 12

HOW TO CONSTRUCT A STREAM TABLE

EQUIPMENT:

1. One piece of sheet metal 6' x 3' x 6"
   (Have metal shop instructor bend the two ends and two sides 6" in from the edge and weld the corners together so that the finished table is 5' x 2' x 6" deep. At one end, cut 1/2" diameter hole. Place an adaptor through the hole (through which a 1/2" plastic tube can be threaded. Secure on the inside of the tank with a washer and bolt.
2. Two gallon bucket
3. Water pump (from an aquarium supply)
4. 2 long strips plastic tubing 1/2" diameter
   - a) one strip long enough to reach from the water pump in the bucket to the front edge of the stream table
   - b) one strip tubing long enough to reach from the outlet of the tank back to the waterpump bucket
5. Clamps, to hold the plastic tubing in place
6. Various texture sands, silt, gravel to place in the tank
7. Several plastic sheets (appr. 6" x 2") to use as baffles, breakwaters, etc.
8. Three wedges of metal, each the width of the tank, to change elevations.
   - a) 2' width x 3" height (for mountain elevation)
   - b) 2' width x 2" height (for foothill elevation)
   - c) 2' width x 1" height (for valley elevation)



NOTE: Remove high wedge and bring up mid-size one to end, for foothills
Remove mid-wedge and bring up small one for valley elevation

NOTE: Students need to monitor the inflow and outflow from the half-filled bucket of water constantly so they are always in balance.

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